NOAA Technical Memorandum ERL ARL-134

ATMOSPHERIC CROSS SECTIONS FOR THE ARCTIC GAS AND AEROSOL SAMPLING PROGRAM, MARCH-APRIL 1983

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Air Resources Laboratory
Silver Spring, Maryland
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UNITED STATES DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Environmental Research Laboratories
Vernon E. Derr, Director

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CONTENTS

FOREWORD

This Technical Memorandum presents, under one cover, the meteorological conditions and air mass characteristics present during 12 Arctic Gas and Aerosol Sampling Program (AGASP) research flights, March 11-April 12, 1983. These data are considered the framework within which analysis of Arctic Haze chemistry and haze aerosol physics may be interpreted.

Analyses and graphs of AGASP data already published are not repeated here except for a few unique meteorological situations that bear on understanding the larger picture. To date, the majority of the AGASP publications have appeared in *Geophysical Research Letters, Vol. 11*, No. 5 pp. 359-472, May 1984, or will appear in a special issue of *Atmospheric Environment* to be published in the summer of 1985.

The Particle Measuring Systems (PMS) ASASP-100X in-situ aerosol probe data and the aircraft-collected meteorological/aerosol/gas data will be the subject of a separate Technical Memorandum. These and all other available support data can be obtained from the following:

Director, AGASP
NOAA/ERL/GMCC
R/E/AR4
325 Broadway
Boulder, CO 80303.

As the reader will observe, Dr. Raatz has produced a large volume of high-quality analyses in a short period of time. In addition to this memorandum, he has contributed nine refereed publications on the AGASP data set. It has been a distinct pleasure and growth experience to have had Wolfgang as a National Research Council Research Associate for the past year. We wish him well in his new career, which he began in October 1984, with the Federal Republic of Germany Weather Service.

Russell C. Schnell
Director, AGASP

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NRC Advisor

Atmospheric Cross Sections for the Arctic Gas and Aerosol Sampling Program, March-April 1983

ABSTRACT. During spring 1983 a series of research flights was conducted over the Arctic as part of the Arctic Gas and Aerosol Sampling Program (AGASP). For each of the flights the synoptic situation is given. A flight log and a cross section of potential temperature along the flight track describe the movement of the aircraft, the type of air mass present, and the meteorological conditions observed. Examples of the horizontal and vertical variability of aerosol, ozone, and meteorological measurements are presented for some unique situations.

INTRODUCTION

During the spring of 1983 the National Oceanic and Atmospheric Administration (NOAA) sponsored a series of research flights over the Arctic to study the so-called Arctic Haze phenomenon. The Arctic Gas and Aerosol Sampling Program (AGASP) was designed to extend into three dimensions the Arctic Haze measurements conducted at surface stations such as those at Barrow, AK; Alert, N.W.T.; and Ny Alesund, Svalbard. A summary of the flight tracks is given in Figure 1.

Measurements on board the aircraft were manifold and included physical and chemical characterizations of aerosols and gases, measurements of radiation, and characterizations of the meteorological conditions. First results of this experiment have been published in *Geophysical Research Letters, Vol. 11*, No. 5, 1984. It is the purpose of this report to present an overview of the meteorological and synoptic conditions present during each flight. Weather maps and cross sections of potential temperature (sometimes moisture mixing ratio as well) describe the horizontal and vertical structure of the atmosphere traversed by the aircraft on each mission. For each flight, a flight log is given describing the vertical and horizontal movement of the aircraft and the type of air mass encountered; meteorological observations of clouds, haze, etc., are also included.

Examples of the horizontal and vertical variability of aerosols, ozone, and meteorological measurements are presented. All times and dates are given in GMT.

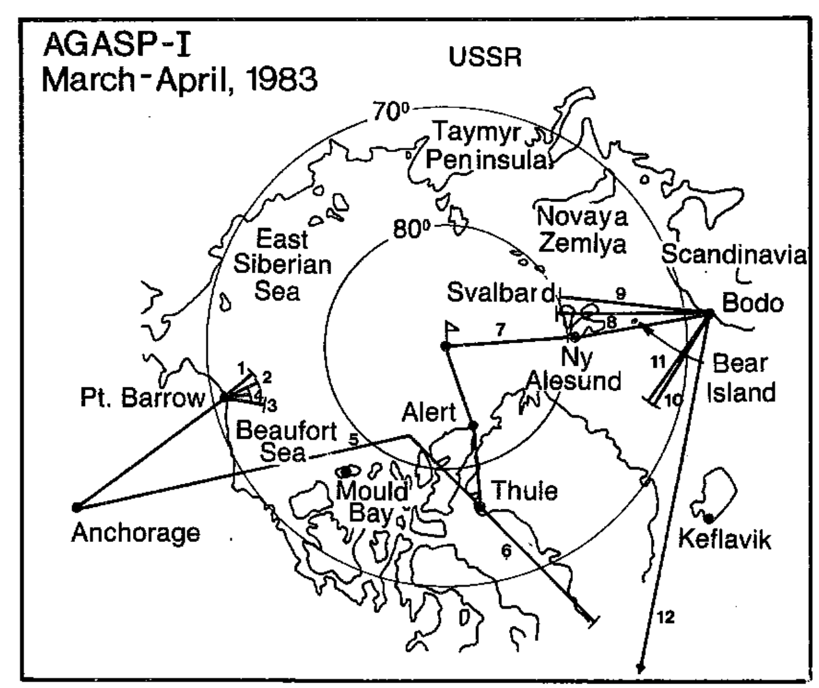

Fig. 1: Approximate flight tracks of the NOAA WP-3D aircraft during the AGASP project, (from Schnell, 1984). Individual flights are numbered in order of occurrence.

1. AGASP Flight No. 1 (March 11/12, 1983)

1.1 Mission Type

The aircraft flew directly from Anchorage, AK, north to Barrow, AK, to obtain a vertical profile and several horizontal runs in the vicinity of Barrow over the ice-covered Beaufort Sea. On its return to Anchorage, the aircraft penetrated a tropopause fold. To characterize this fold, the aircraft changed flight level and returned northward for a period before resuming its final track to Anchorage. The horizontal projection of the flight track is given in Figure 2. Total flight time was 11 h 30 min.

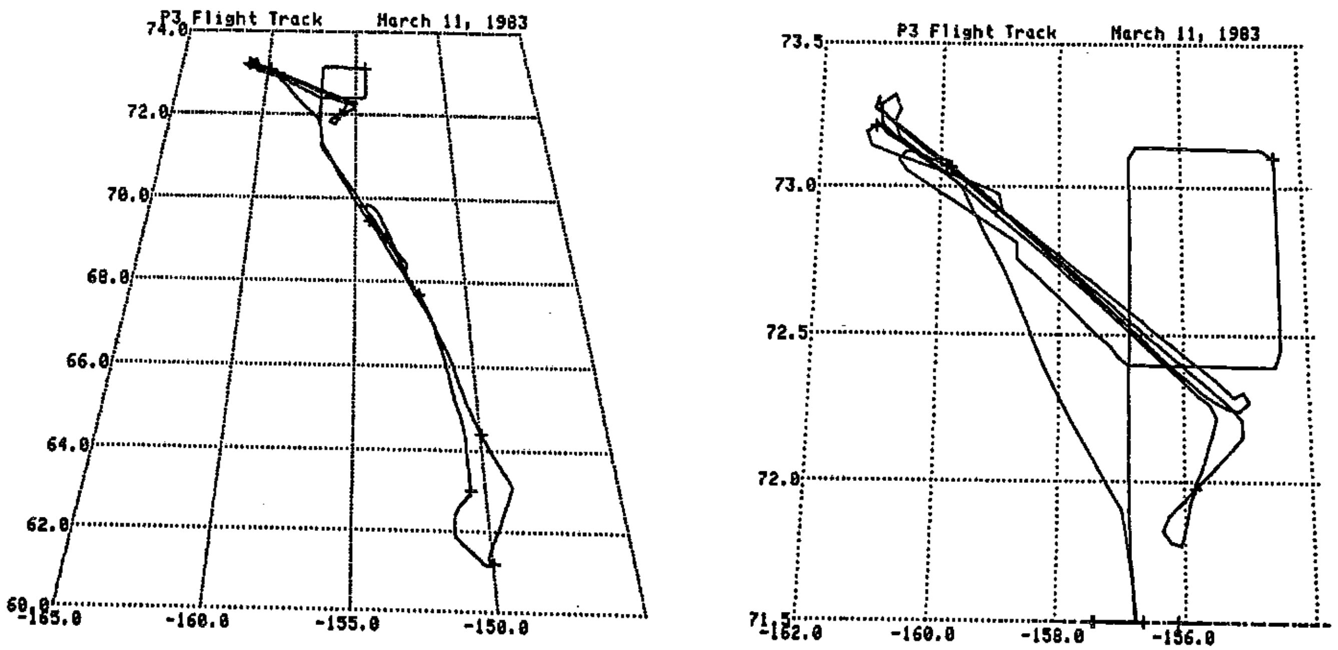

Fig. 2: Horizontal projection of the aircraft's flight track over Alaska, March 11, 1983.

1.2 Synoptic Situation

The lower tropospheric pressure distribution (850 mb) was characterized by a cyclonic pressure system located over the Gulf of Alaska and an anticyclone located over the East Siberian Sea-Chukchi Sea (Figure 3). A strong baroclinic zone (Arctic front), situated across the interior of Alaska, was characterized by a strong temperature gradient. The upper tropospheric 500-mb pressure distribution (Figure 4) was characterized by two anticyclones, to the northwest and southeast of Alaska, and two low-pressure systems to the northeast and southwest.

1.3 Flight Log

19:19	take off
19:19-19:40	ascent within Pacific air
19:40	7/8 St below, haze visible for the first time and visible throughout the rest of the flight until sunset
19:45	frontal passage at 63.13 ° N, 480 mb

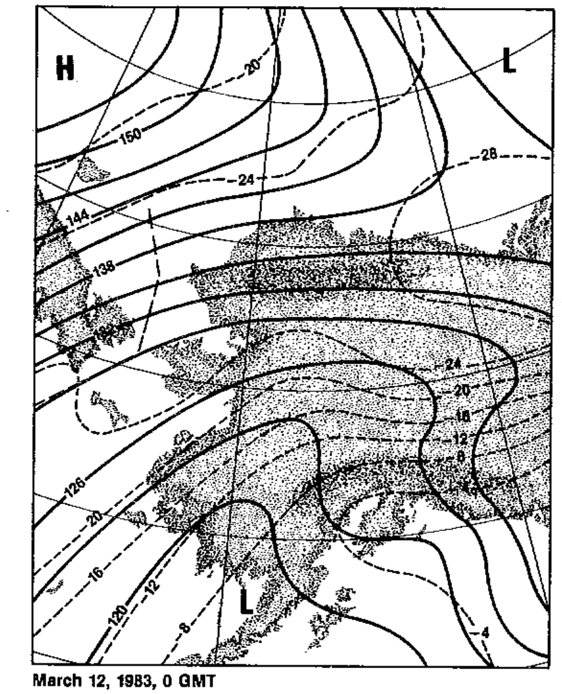

Fig. 3: The 850-mb pressure height (geopotential decameters, solid isolines) and temperature (° C, broken isolines) distribution over Alaska, March 12, 1983, 0000 GMT.

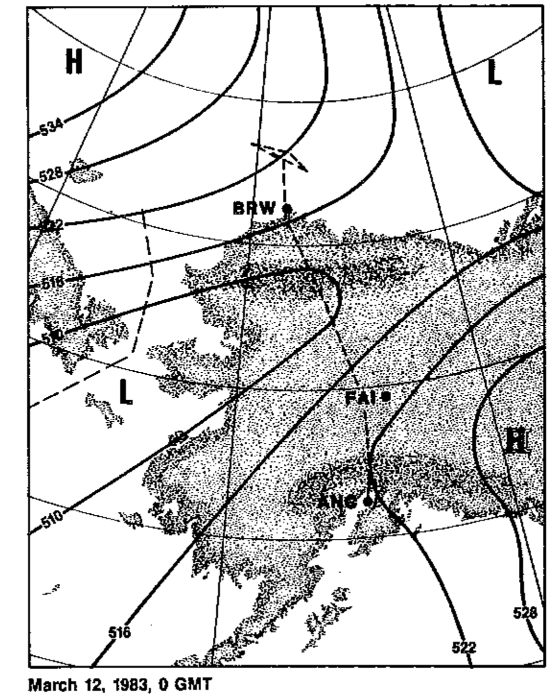

Fig. 4: The 500-mb pressure height (geopotential decameters) and approximate flight track (broken lines) over Alaska, March 12, 1983 0000 GMT.

19:45-20:47	horizontal track at 486 mb, stable layer containing stratospheric air and penetrating lower part of the tropopause fold (Raatz et al., 1985a)
19:50	8/8 St, 7/8 Ci, turbulence, flying in clear air between clouds
20:15	5/8 St very thin, no more high-level clouds
20:31	very thin St between mountains, haze top looks more dense and darker
20:40	no clouds
20:48	frontal passage at 68.56 ° N, 487 mb
20:48-21:34	horizontal track at 487 mb within upper tropospheric (Arctic) air
21:34-22:26	descent (Schnell and Raatz, 1984)
21:51	low-level thin St clouds near coastline
22:26-2:51	various flight levels within Arctic air
2:51	at 69.70 ° N, 377 mb, penetration of tropopause
2:51-4:40	various flight levels within stratospheric air containing El Chichon debris (Raatz et al., 1985a)
4:30	sunset
4:40	penetration of tropopause at 64.57 ° N, 265 mb
4:40-5:37	final descent in upper tropospheric/Pacific air

1.4 Atmospheric Cross Section

A latitude-altitude cross section of potential temperature for March 11/12, 1983 (Figure 5) was constructed along the flight track on the basis of radiosonde data obtained over Anchorage (ANC), Fairbanks (FAI), and Barrow (BRW); data from dropsondes released by the aircraft at 71.43 ° N and 69.48 ° N, and data recorded by the aircraft along its flight track.

The low level Arctic front is indicated between the Alaska Range to the south and the Brooks Range to the north . The upper troposphere is dominated by the tropopause fold and its extension into a horizontal stable layer (Raatz et al., 1985a). Note the very stable air near the surface north of the Brooks Range.

1.5 Distribution of Ozone, Condensation Nuclei, and Scattering Extinction Coefficient Within the Tropopause Fold

In the upper portion of the cross section of potential temperature (Figure 5) we recognize the features of a tropopause fold. Between 68 ° N and 71 ° N there is a region associated with an upper-level baroclinic zone where stratospheric air intrudes into the troposphere. The distribution of stratospheric ozone within this fold is described in Figure 6. A tongue of ozone in excess of 50 nb reaches to almost 600 mb. The maximum, in excess of 175 nb, is found at 300 mb. Figure 6 also presents the corresponding distribution of condensation nuclei (CN) concentration and extinction coefficient σ_{sp}. CN concentrations within the fold are on the order of 400 cm^{-3}; however, there is a dramatic increase of CN to a maximum of 1800 cm^{-3} associated with the strong ozone concentration gradient in the upper part of the fold. Note that the CN maximum is located within the cyclonic side of the tropopause fold. This case seems to represent a "polluted" Arctic stratosphere most likely resulting from the influence of El Chichon volcanic debris (Shapiro et al., 1984).

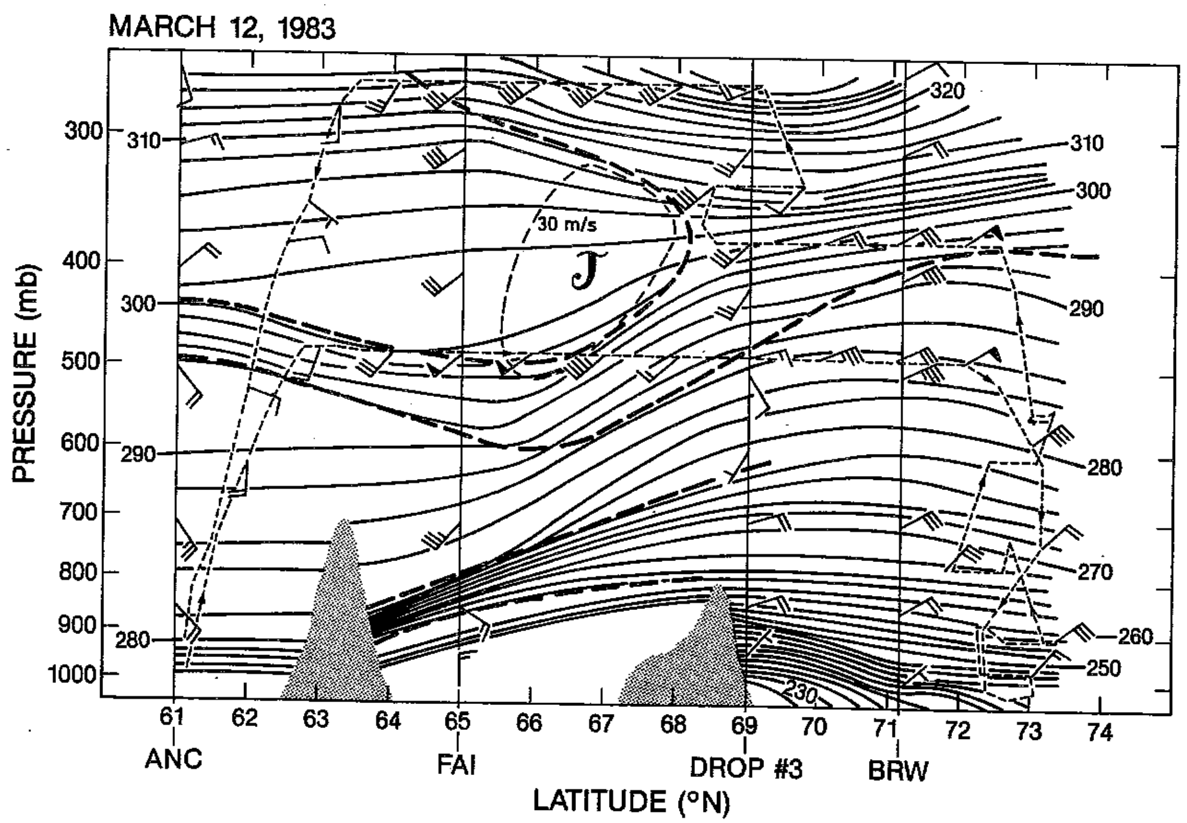

Fig. 5: Latitude-altitude cross section of potential temperature (K) and wind (kt), March 11/12, 1983. The tropopause and the Arctic front are indicated by thick broken lines. The aircraft flight track is indicated by the thin broken line. The jet core is indicated by the 30 m/s^{-1} isotach.

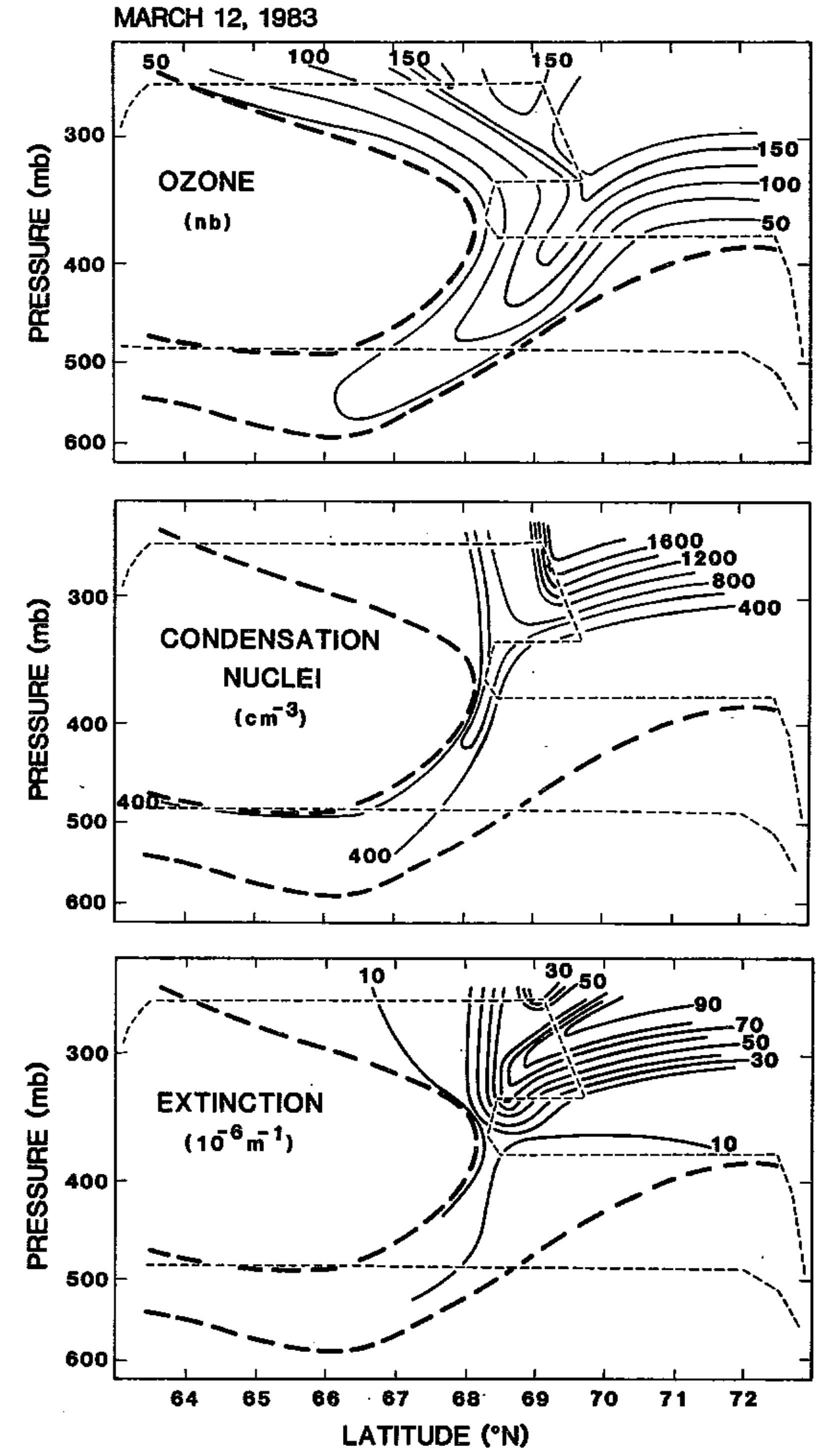

Fig. 6: Horizontal and vertical distribution of stratospheric ozone and CN concentrations, and of extinction coefficients (σ_{sp}) within the tropopause fold, March 11/12, 1983 (Raatz et al., 1985a). The thick broken line describes the boundary of the fold, the thin broken line indicates the aircraft flight track.

2. AGASP Flight No. 2 (March 13/14, 1983)

2.1 Mission Type

The aircraft flew directly from Anchorage, AK, to Barrow, AK, to obtain a vertical profile and a long horizontal run within a haze layer in the vicinity of Barrow over the ice-covered Beaufort Sea. A low-level jet north of the Brooks Range was discovered en route (Shapiro, 1984). The flight track almost reached 75 ° N, the northernmost position over the Beaufort Sea during AGASP flights 1-4. The horizontal projection of the flight track is given in Figure 7. Total flight time was 8 h 30 min.

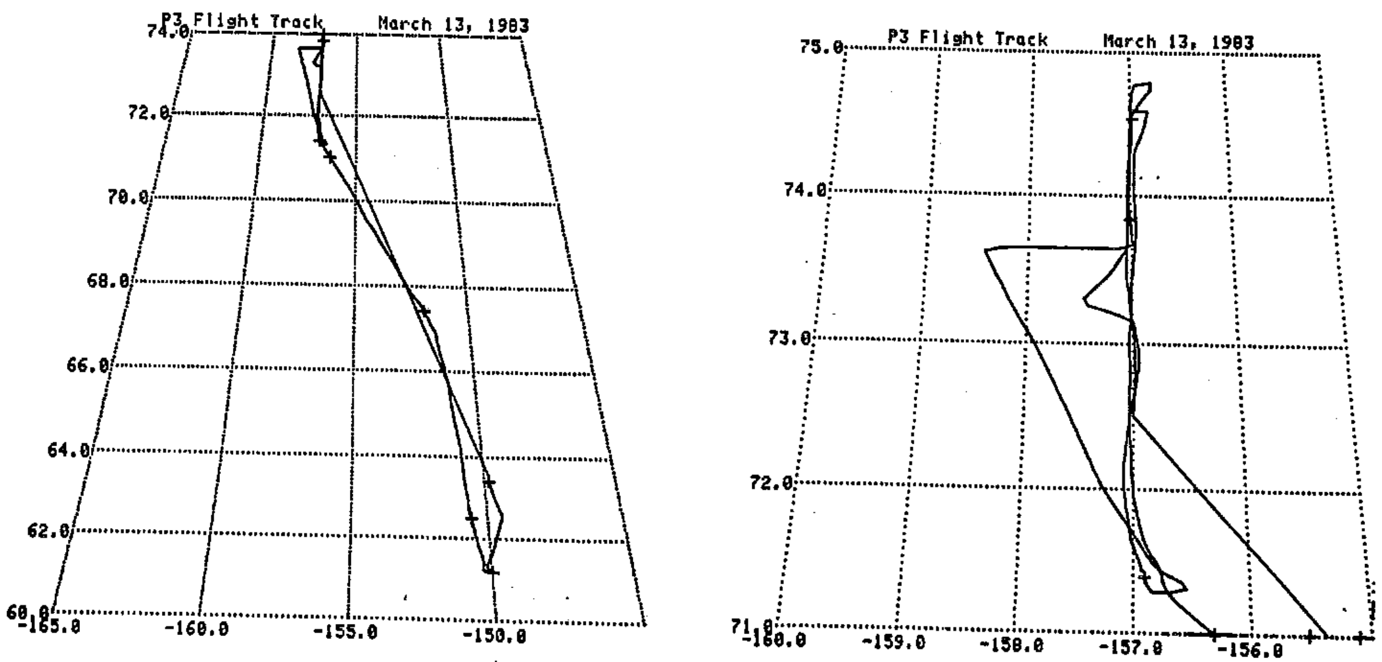

Fig. 7: Horizontal projection of the aircraft's flight track over Alaska, March 13/14, 1983.

2.2 Synoptic Situation

The lower tropospheric pressure distribution (850 mb) was characterized by a cyclonic system located over the Gulf of Alaska and an anticyclone located over the East Siberian Sea-Chukchi Sea (Figure 8). A baroclinic zone (Arctic front) was situated across the interior of Alaska near the Brooks Range. Compared with March 12, the overall pressure distribution has not changed significantly. However, the anticyclone moved closer to the Beaufort Sea area, and the Arctic front lost some of its intensity while moving northward. The upper tropospheric pressure distribution (500 mb) was characterized by an anticyclone over the East Siberian Sea-Chukchi Sea and a high-pressure ridge extending from the Yukon Territory over the interior of Alaska (Figure 9). Both anticyclones shown in the figure were separated by a weak low-pressure trough. In comparison with March 12, the cyclonic influence has weakened, and the continental anticyclone to the southeast has increased its influence.

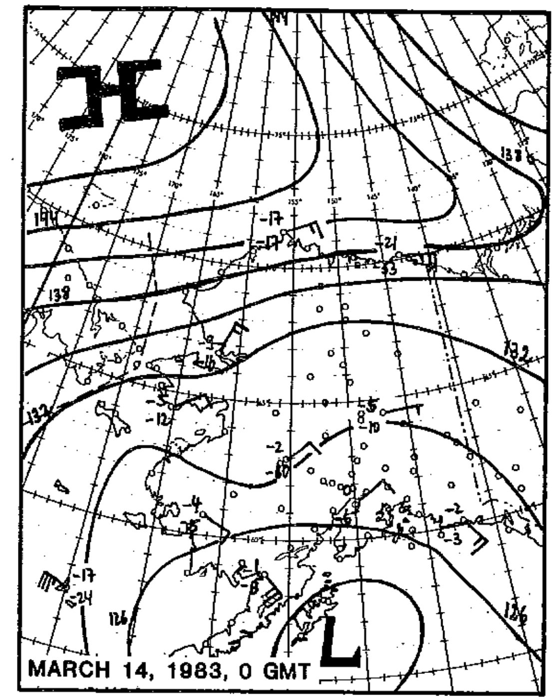

Fig. 8: The 850-mb pressure height (geopotential decameters) distribution over Alaska, March 14, 1983, 0000 GMT, with temperatures in ° C and winds in kt.

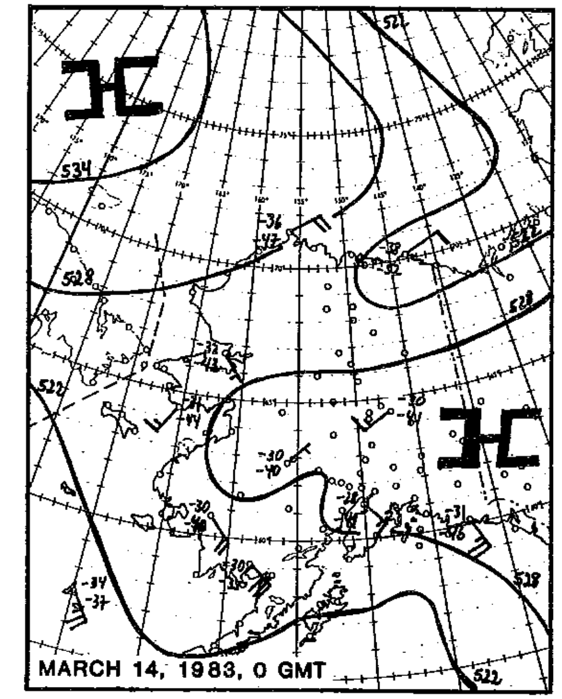

Fig. 9: The 500-mb pressure height (geopotential decameters) distribution over Alaska, March 14, 1983, 0000 GMT, with temperatures in ° C and winds in kt.

2.3 Flight Log

19:15	take off
19:15-19:34	ascent within Pacific air
19:34-20:29	horizontal track at 463 mb within upper tropospheric (polar continental) air
(19:45-22:02 data loss times from hand notes)	
19:47	Ci, Cs to the east, patchy to the north
19:53	haze reported for the first time and was present throughout the rest of the flight until sunset
20:07	low Sc over mountains north of Yukon River, thin clouds just above flight level
20:26	low-level clouds north of Brooks Range
20:29-?	descent and penetration of an air mass boundary
?-22:02	various levels in Arctic air
22:04-22:40	descending profile (Schnell and Raatz, 1984)
22:10-2:44	various levels in Arctic air, patches of low-level clouds reported once in a while
2:32-2:58	ascending profile (Schnell and Raatz, 1984)
2:44	frontal passage at 68.47 ° N, 626 mb
2:44-3:30	ascent through upper tropospheric (polar continental) air
3:31	penetration of tropopause at 64.87 ° N, 265 mb
3:31-3:49	various levels within the stratosphere
3:49	penetration of tropopause at 63.33 ° N, 310 mb
3:49-4:23	final descent, Pacific air

2.4 Atmospheric Cross Section

A latitude-altitude cross section of potential temperature (Figure 10) was constructed along the flight track on the basis of radiosonde data obtained over Anchorage (ANC), Fairbanks (FAI), and Barrow (BRW), and data recorded by the aircraft along its flight track. No dropsondes were released.

Between the Alaska Range to the south and the Brooks Range to the north a weak low-level Arctic front is indicated. Along the north face of the Brooks Range there is a pool of cold air over the continent in which near-surface air temperatures are lower than those over the ice. The lower troposphere north of the Brooks Range is very stable. In the midtroposphere a weak frontal zone is indicated; it separates polar continental air associated with the anticyclone to the southeast from Arctic air. Within the Arctic air mass, pronounced variability in the aerosol parameters and the presence of haze were noted (Raatz et al., 1985b). Stratospheric air was penetrated for a short period toward the end of the flight.

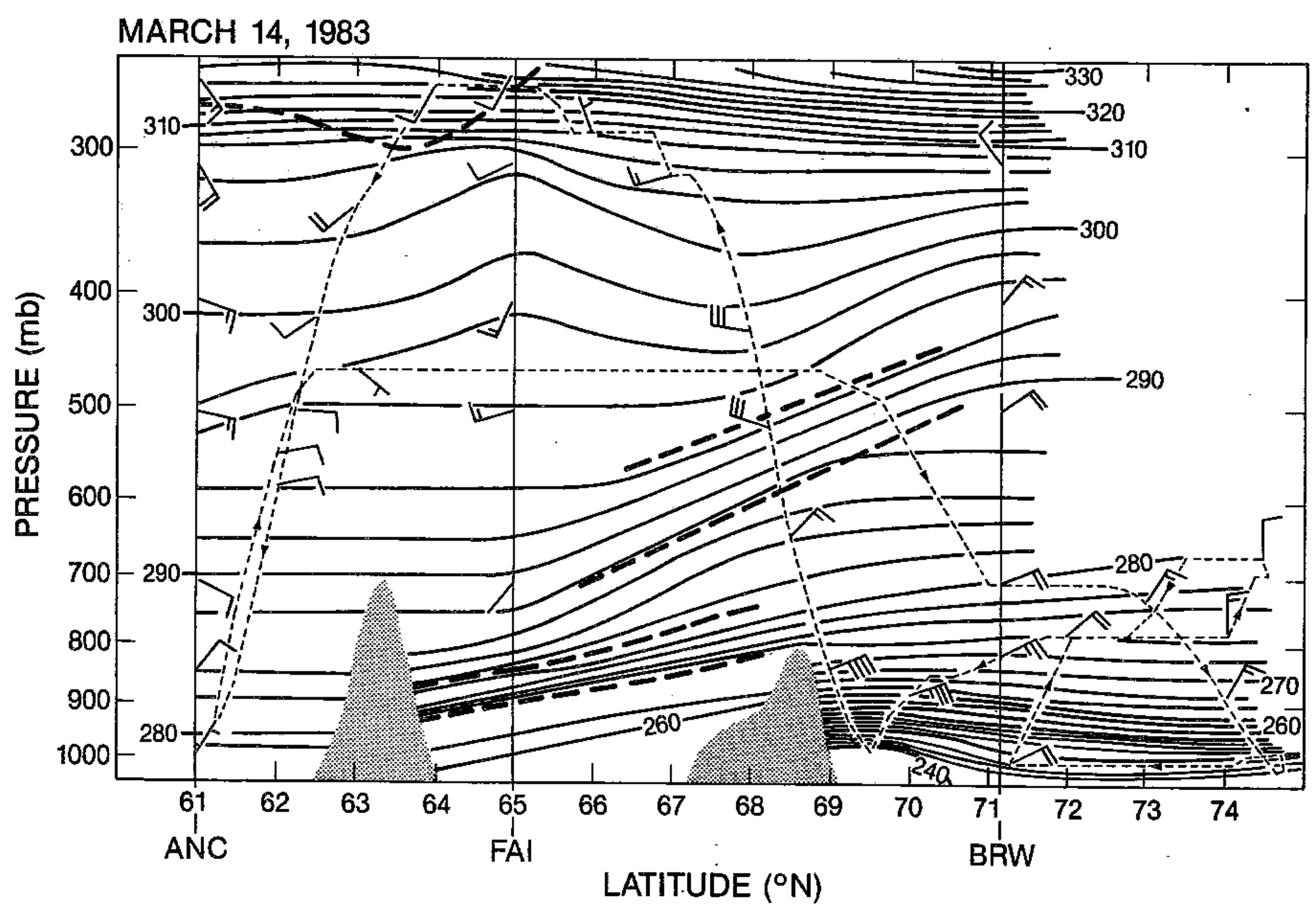

Fig. 10: Latitude-altitude cross section of potential temperature (K) and wind (kt), March 13/14, 1983. The tropopause and the boundaries of tropospheric fronts are indicated by thick broken lines. The aircraft flight track is indicated by the thin broken line.

2.5 Vertical and Horizontal Distribution of Condensation Nuclei, Extinction Coefficient, Ozone, and Relative Humidity near Barrow

On March 13/14, at the height of the Arctic Haze episode, the range of the extinction values was $(10–60) \times 10^{-6}$ m^{-1}, as shown in Figure 11. At 1010 mb, near Barrow (71 °N), the highest extinction is recorded; it decreases rapidly from 60×10^{-6} to 25×10^{-6} m^{-1} as one moves northward at the same level. At intermediate pressure levels (780 mb), the range of values is $(10–30) \times 10^{-6}$ m^{-1}, again showing abrupt changes at one constant level. Above 750 mb, extinction values are lowest.

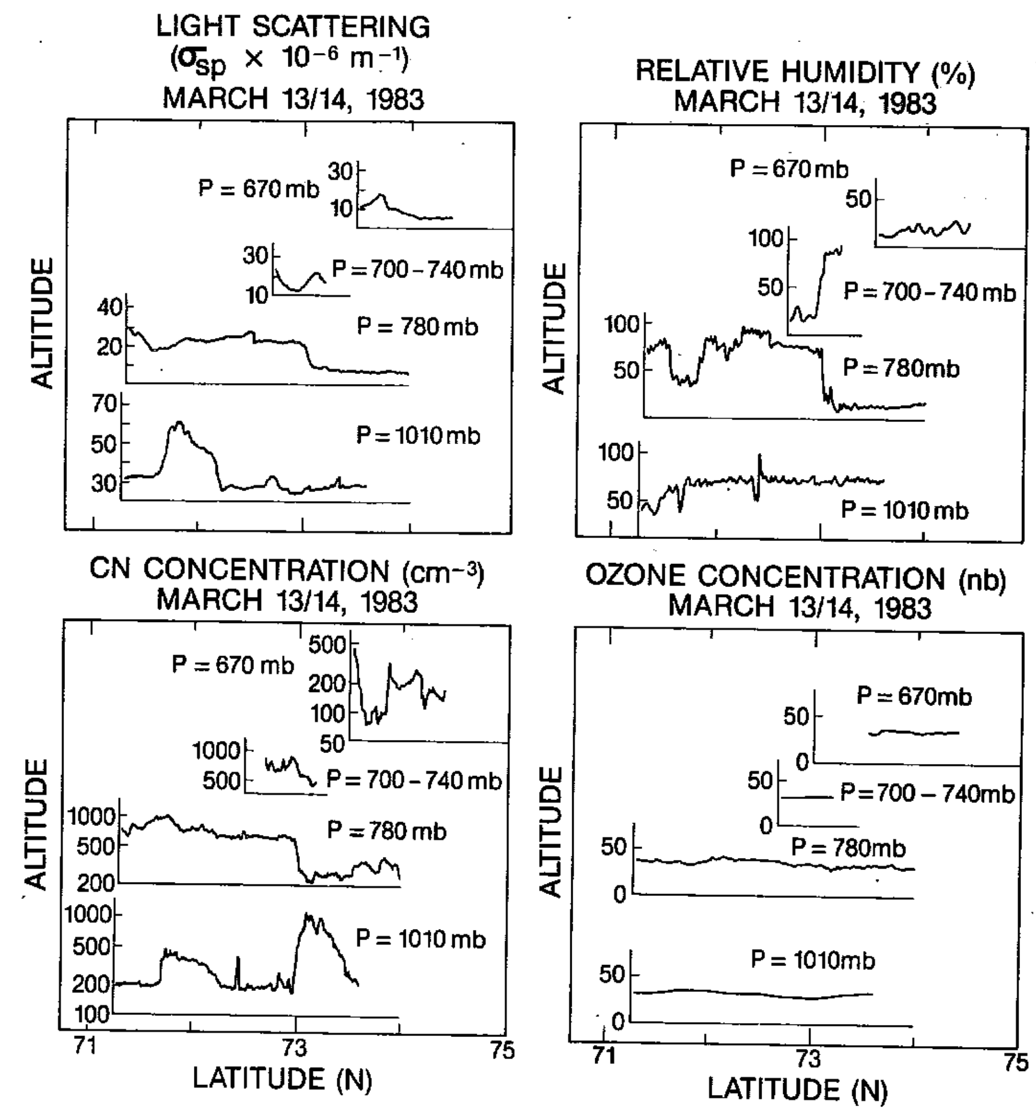

Fig. 11: Latitude-altitude cross sections of extinction coefficient, relative humidity, condensation nuclei and ozone, March 13/14, 1983 (Raatz et al., 1985b).

The latitude-height cross section of relative humidity for the same day (Figure 11) suggests that in the surface inversion layer the variations in extinction are not related to variations in relative humidity. At the intermediate level, however, extinction values and relative humidity seem to correlate. Dry air appears to have lower extinction values than moist air. The temperature profile (Figure 10) shows that the top of the moist surface inversion is located at about 810 mb over Barrow. Flying at about 780 mb, the aircraft was operating just at the top of the surface inversion, sometimes below and sometimes above it. From Figure 11 it appears that the moist air is characteristic for the air mass in the surface inversion layer, whereas the dry air is characteristic for the air mass aloft. For the upper two flight levels a correlation between extinction and relative humidity no longer exists.

CN concentration (Figure 11) varies between 70 and 1000 cm^{-3}. High values of up to 1000 cm^{-3} are observed at all but the highest level; concentrations above 700 mb are generally lower. Within the surface inversion layer the peak in CN concentrations near Barrow (71 °N) seems to correlate with the increased extinction values. On the other hand, at the same level but north of 73 °N, CN concentrations and extinction values do not correlate. At the intermediate level, dry and less-turbid air appears to be associated with higher CN counts south of 73 °N and with lower CN counts north of 73 °N.

On this day, ozone concentrations were low (20-25 nb) and uniform, showing little variation horizontally and vertically (Raatz et al., 1985b).

3. AGASP Flight No. 3 (March 15/16, 1983)

3.1 Mission Type

The aircraft flew directly from Anchorage, AK, to Barrow, AK, to obtain a vertical profile and to make several horizontal runs in the vicinity of Barrow over the ice-covered Beaufort Sea. In addition, the low-level jet along the northern face of the Brooks Range was characterized by releasing several dropsondes over the area (Shapiro, 1984). The horizontal projection of the flight track is given in Figure 12. Total flight time was 10 h.

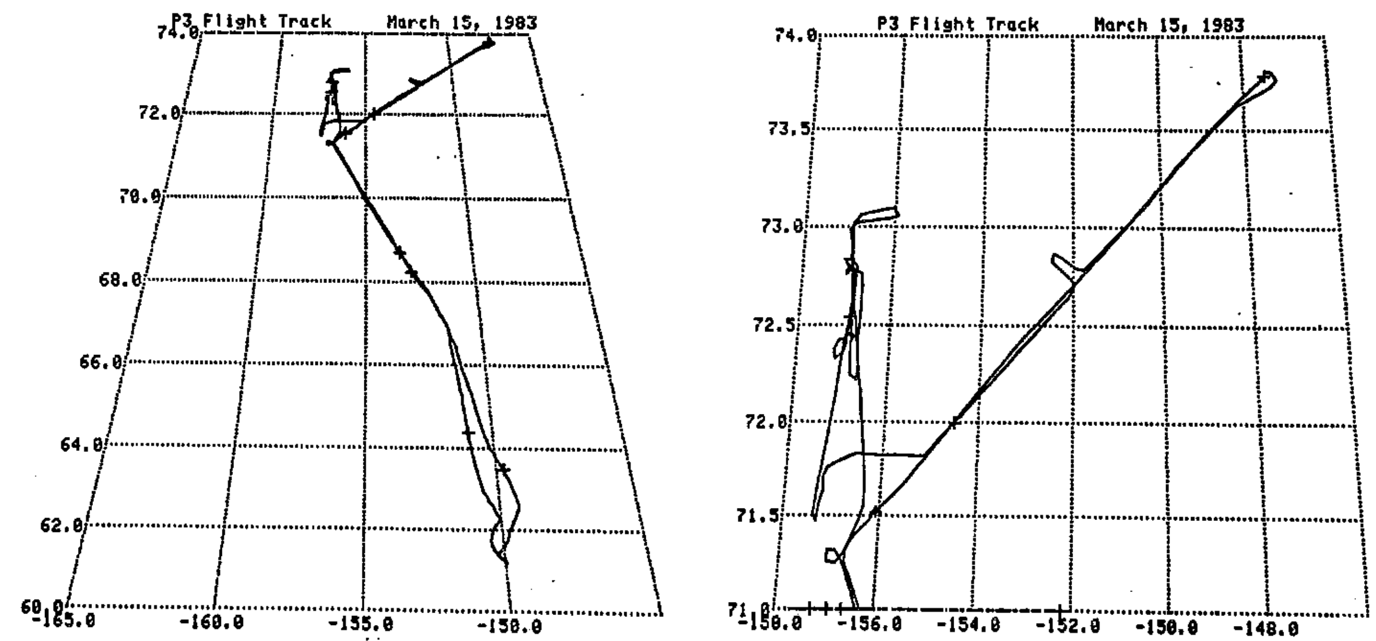

Fig. 12: Horizontal projection of the aircraft's flight track over Alaska, March 15/16, 1983.

3.2 Synoptic Situation

The lower tropospheric pressure distribution (850 mb) was characterized by a cyclonic pressure system over the Gulf of Alaska, a weak low-pressure trough over the interior of Alaska, and an anticyclone over the Chukchi Sea-Beaufort Sea area (Figure 13). In contrast to March 14, the anticyclone has increased its influence over northern Alaska, and the Arctic front has disappeared. The upper tropospheric pressure distribution (500 mb) was indifferent over Alaska, anticyclones were located outside Alaska to the northwest and southeast, and cyclones were located to the northeast and southwest (Figure 14).

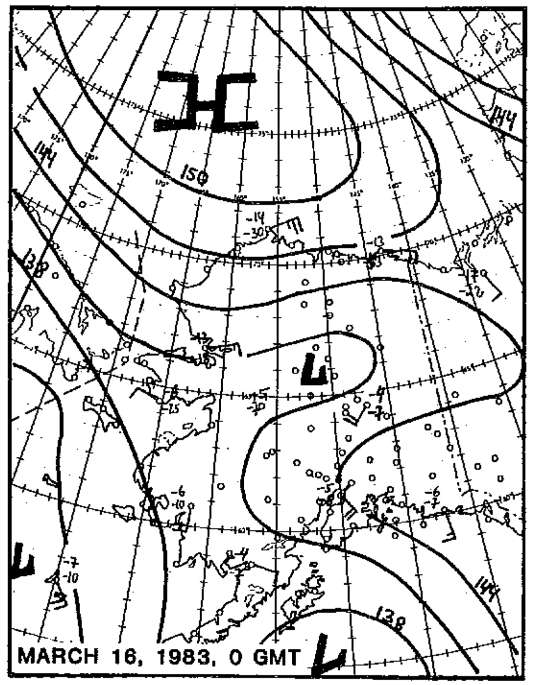

Fig. 13: The 850-mb pressure height (geopotential decameters) distribution over Alaska, March 16, 1983, 0000 GMT, with temperatures in °C and winds in kt.

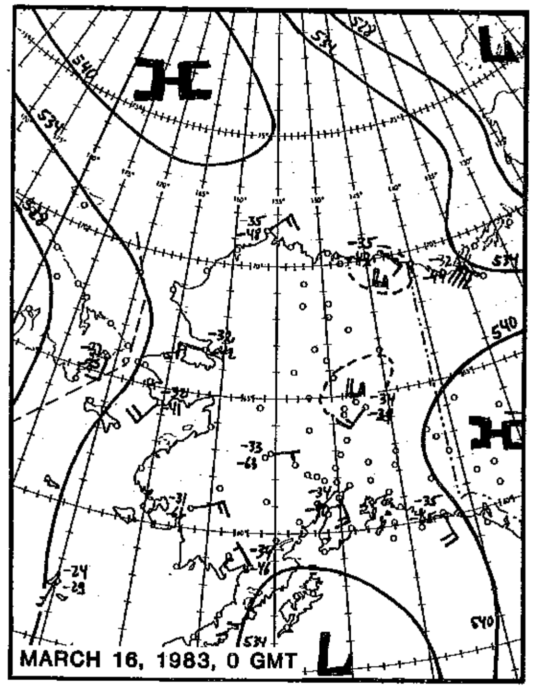

Fig. 14: The 500-mb pressure height (geopotential decameters) distribution over Alaska, March 16, 1983, 0000 GMT, with temperatures in °C and winds in kt.

3.3 Flight Log

19:26	take off
19:26-21:07	ascent and various levels, upper tropospheric (polar continental) air
20:25	8/8 Sc, bright whitish horizon
21:05	8/8 Sc, bright whitish horizon, turbulence
21:07	frontal passage at 68.82 °N, 395 mb
21:07-22:24	horizontal track at 395 mb, upper tropospheric (Arctic) air
21:19	in diffuse cloud or whitish haze, ground becomes obscured
21:48	amorphous haze, no clouds, poor visibility downward, from now on haze was positively identified until 3:05
22:24-23:18	descent in Arctic air (Schnell and Raatz, 1984)
23:18-3:12	various flight levels, Arctic air
23:20	no clouds, turbulence
1:48	4/8 St along coastline, three haze bands visible
2:43	2/8 As above aircraft, hazy below, clear air between cloud and haze
3:05	2/8 St, 7/8 As, light turbulence, mountains visible, no haze
3:12	frontal passage at 67.99 °N, 698 mb
3:12-3:37	ascent within upper tropospheric (polar continental) air
3:37-4:17	horizontal track at 344 mb, upper tropospheric (polar continental) air
4:17-4:48	final descent

3.4 Atmospheric Cross Section

A latitude-altitude cross section of potential temperature (Figure 15) was constructed along the flight track on the basis of radiosonde data obtained over Anchorage (ANC), Fairbanks (FAI), and Barrow (BRW); data from dropsondes released by the aircraft at 69.20 °N and 73.02 °N; and data recorded by the aircraft along its flight track.

The low-level Arctic front present on earlier occasions has disappeared. North of the Brooks Range there is a very stable air mass in the lower troposphere and a pool of cold air along the northern slopes of the Brooks Range. This cold pool and its associated low level jet have been studied in detail by releasing a total of seven dropsondes north of the Brooks Range (Shapiro, 1984). In the midtroposphere a frontal zone is identified that separates Arctic air from polar continental air. During this flight no stratospheric air was encountered.

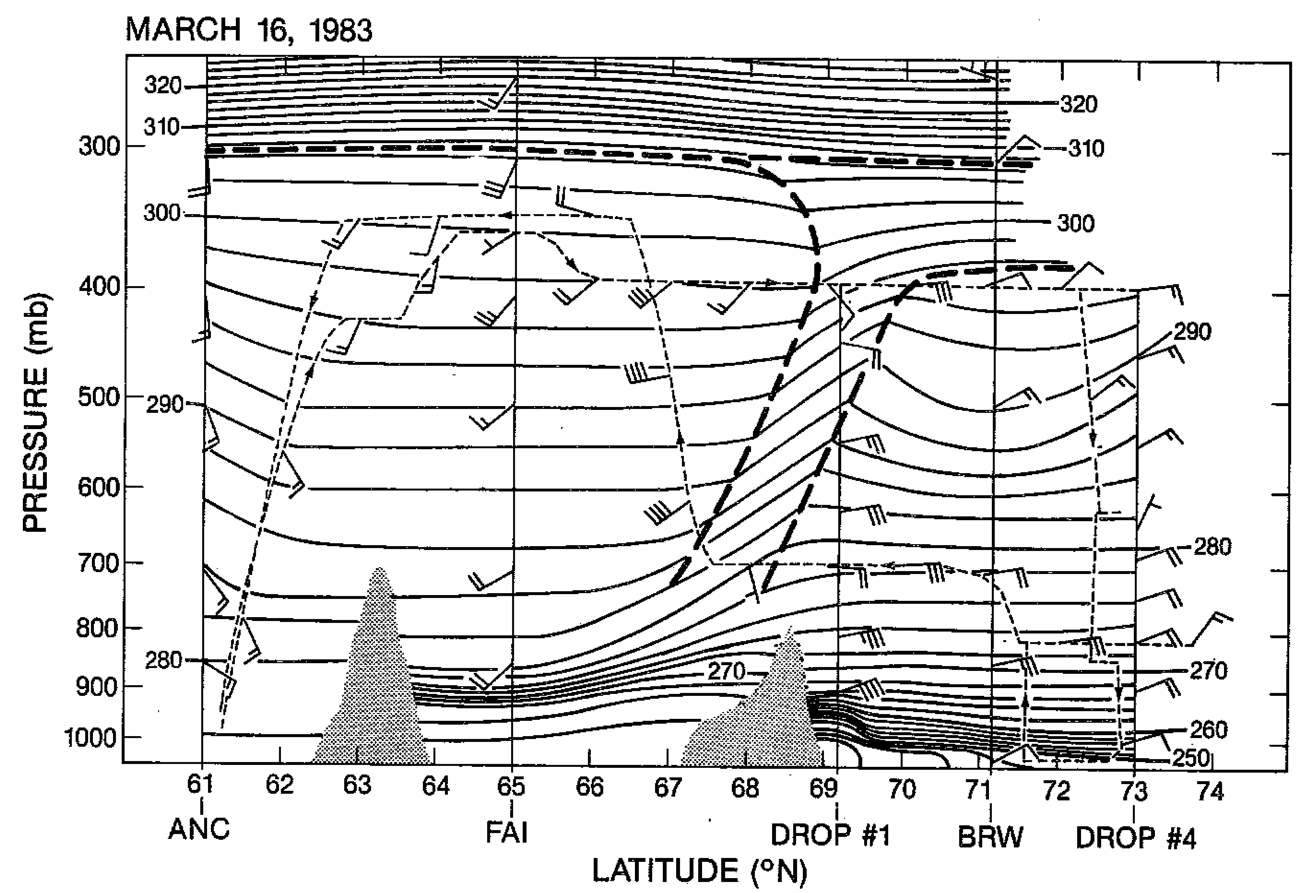

Fig. 15: Latitude-altitude cross section of potential temperature (K) and wind (kt), in March 15/16, 1983. The tropopause and the baroclinic zone are indicated by the thick broken lines. The aircraft flight track is indicated by the thin broken lines.

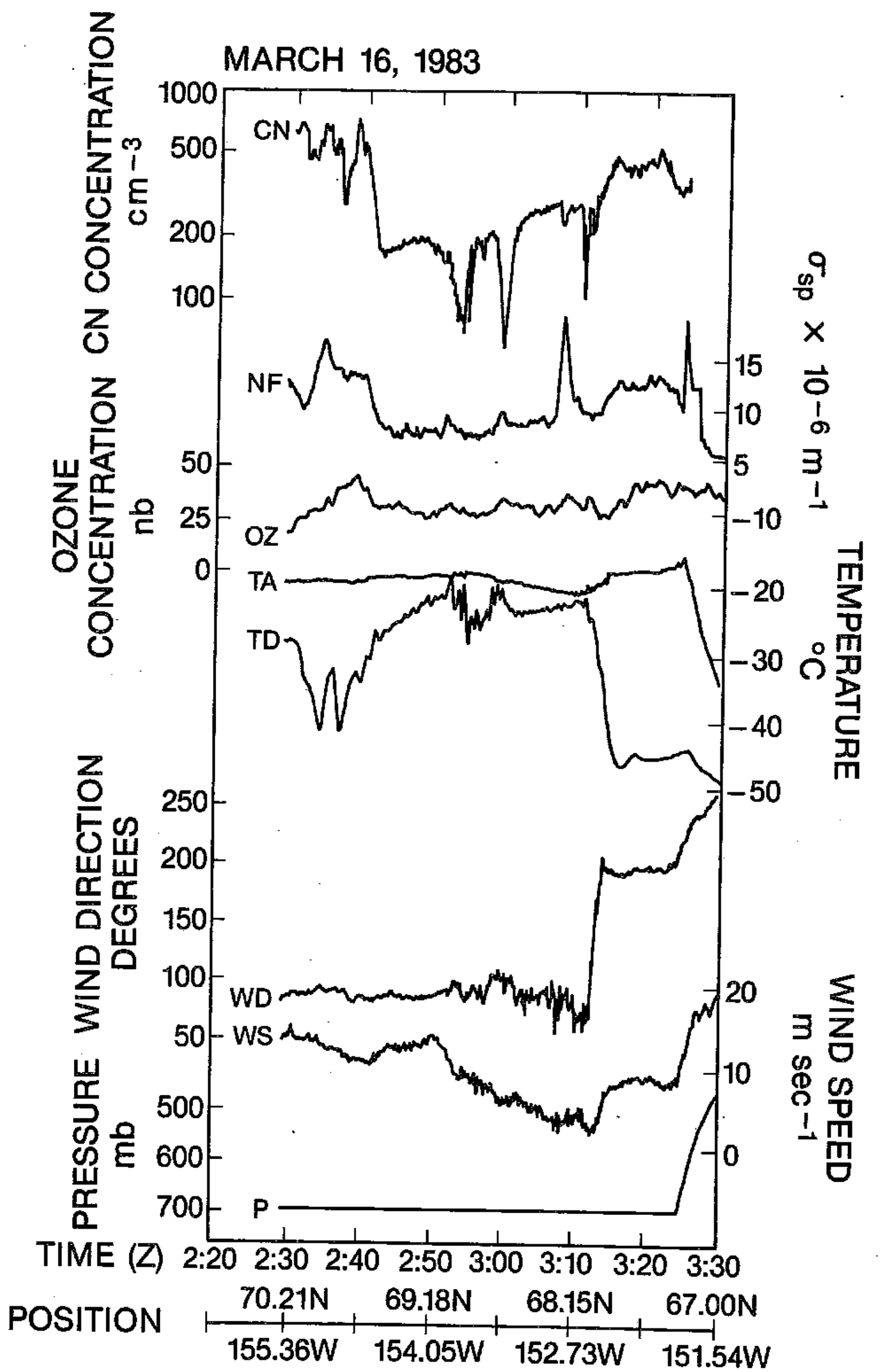

Fig. 16: Time series of aerosol and meteorological parameters from 0230 GMT to 0330 GMT, March 16, 1983, while the aircraft passed through a midtropospheric front.

3.5 Meteorological and Aerosol Air Mass Characteristics Across a Midtropospheric Front

Figure 16 presents a time series of selected data recorded between 0230 and 0330 GMT on March 16, 1983, while the aircraft flew southbound between 70.21 °N, 155.36 °W and 67.00 °N, 151.54 °W. The flight altitude was 698 mb for most of the time. At 0324 GMT the aircraft began ascending.

The front was encountered at 0313 GMT as indicated by a pronounced shift in wind direction from 90 ° to 197 ° associated with a temporary wind speed minimum. Air temperatures indicate a rise of about 2 °C across the front. During the last 20 min before frontal passage, relative humidities (not shown) averaged 70% in the continental Arctic air mass and changed to about 7% in the continental polar air. It is puzzling why the continental Arctic air at this level was so moist, because Barrow's profile at the same level showed only 24% RH. These lower relative humidities are still present in the first part of the time series (0230-0240 GMT) when the aircraft was close to Barrow. The aircraft data as well as dropsonde data, however, indicate that for reasons unknown, the continental Arctic air near the Brooks Range contained more moisture than the continental Arctic air just south of Barrow. South of the front the continental polar air appears very dry, but another independent measurement cannot be obtained from the Fairbanks radiosonde data, since Fairbanks seems to be still within moist subpolar maritime air. However, there is no temperature difference between the subpolar maritime and the continental polar air masses to support the differences in moisture.

Ozone concentrations show a slight increase across the front, going from continental Arctic into continental polar air. Similarly, aerosol extinction and CN concentrations slightly increase. It appears that the frontal zone is a zone of accumulated ozone and CN concentrations, whereas the air mass characteristics to the south and north do not differ significantly.

4. AGASP Flight No. 4 (March 17/18, 1983)

4.1 Mission Type

The aircraft flew directly from Anchorage, AK, to Barrow, AK, to obtain a vertical and radiation profile in the vicinity of Barrow over the ice-covered Beaufort Sea. During the flights over the Beaufort Sea, the aircraft penetrated the Arctic anticyclone, in contrast to the previous flights, which had been within a so-called transport zone of Arctic Haze (Raatz, 1985; Raatz et al., 1985a). The horizontal projection of the flight track is given in Figure 17. Total flight time was 6 h 45 min.

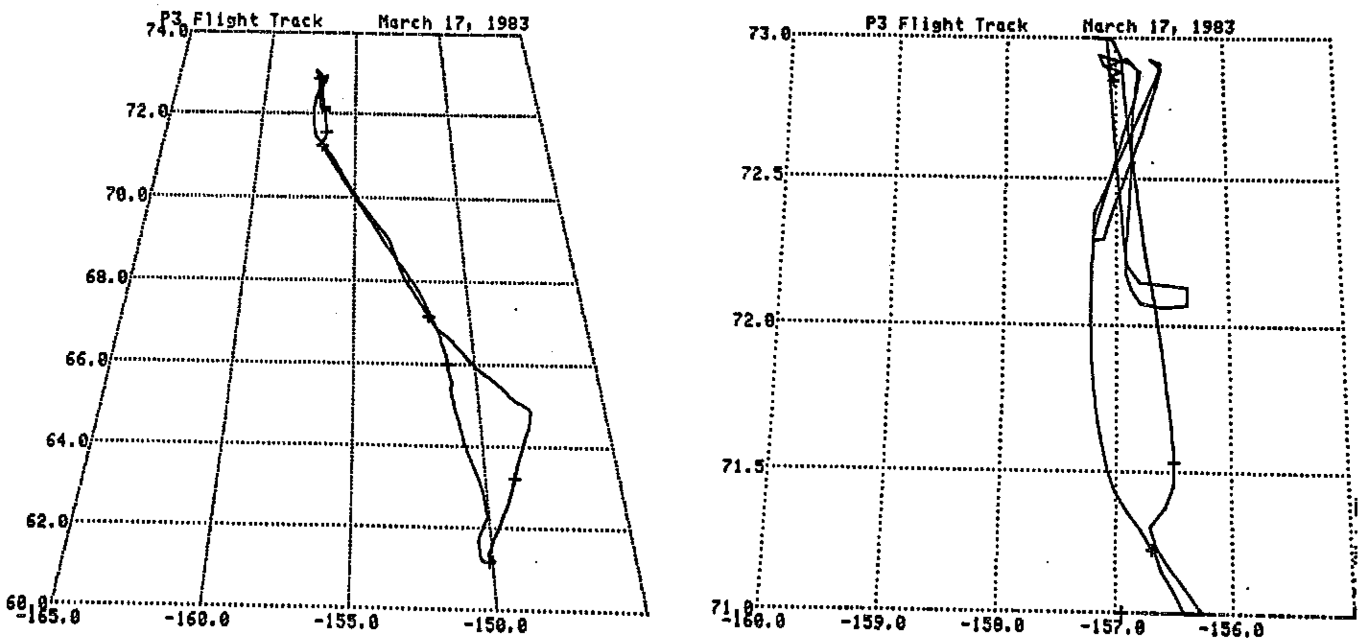

Fig. 17: Horizontal projection of the aircraft's flight track over Alaska, March 17/18, 1983.

4.2 Synoptic Situation

The lower tropospheric pressure distribution (850 mb) was characterized by an anticyclone over the Beaufort Sea that extended into the Northwest Territories of Canada, where it had combined with the continental anticyclone (Figure 18). A small low-pressure system was suggested between Barrow and Barter Island. A frontal zone was located to the south over the Aleutian Islands, whereas most of Alaska was under weak pressure gradients. The upper tropospheric pressure distribution (500 mb) was indifferent (Figure 19). A high-pressure ridge that extended from the northeast Pacific was suggested over southwest Alaska. The overall pressure distribution was anticyclonic, but pressure gradients were weak. The significant difference in pressure distribution between March 11/12 and March 17/18 has been discussed in detail (Raatz et al., 1985a).

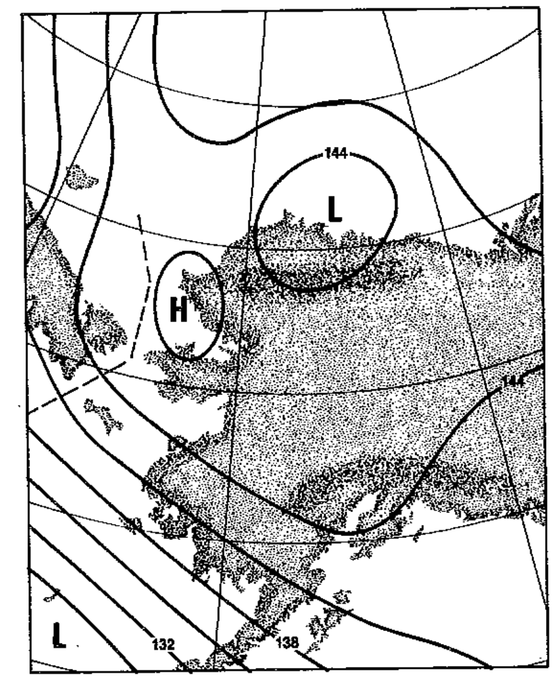

Fig. 18: The 850-mb pressure height (geopotential decameters) distribution over Alaska, March 18, 1983, 0000 GMT.

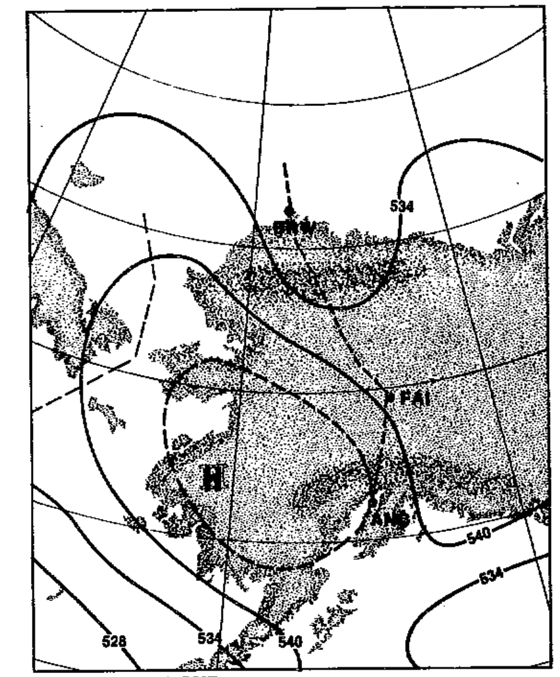

Fig. 19: The 500-mb pressure height (geopotential decameters) distribution over Alaska, March 18, 1983, 0000 GMT, and approximate flight track (broken line).

4.3 Flight Log

19:24	take off
19:24-19:50	ascent in polar continental and stratospheric air
19:50-22:34	horizontal track at 392-396 mb within stratospheric air
20:04	amorphous whitish haze, there seems to be a clear layer between lower and upper haze, whitish haze observed during the rest of the flight
20:34-21:15	8/8 Sc, overall amorphous whitish haze with some layering
21:34	4/8 St, haze and cloud blend into each other
22:04	4/8 Sc in patches, blue horizon between ice and haze aloft
22:32	2/8 Sc, clouds in bands along coastline
22:34-23:25	descent (Schnell and Raatz, 1984), Arctic air and subsiding stratospheric air (Raatz et al., 1985a)
23:25-23:42	horizontal track at 1011 mb, Arctic air
23:42-0:11	ascent
0:11-0:40	horizontal track at 316 mb, stratospheric air
0:40-1:00	ascent
1:00-1:30	horizontal track at 290 mb, upper tropospheric air
1:30-2:05	final descent

4.4 Atmospheric Cross Section

A latitude-altitude cross section of potential temperature (Figure 20) was constructed along the flight track on the basis of radiosonde data obtained over Anchorage (ANC), Fairbanks (FAI), and Barrow (BRW), and data recorded by the aircraft along its flight track. No dropsondes were released.

While flying northward, the aircraft entered a stable upper tropospheric layer that contained subsiding stratospheric air (Raatz et al., 1985a). During its descent over the Beaufort Sea, the aircraft penetrated the Arctic anticyclone, again finding subsiding stratospheric air (Raatz et al., 1985a). On its way back to Anchorage, the aircraft flew through stratospheric air at the 316-mb level but not at the upper 290-mb level. Vertical and horizontal temperature gradients were weak in the midtroposphere. Stable air masses were present in the low troposphere near the surface.

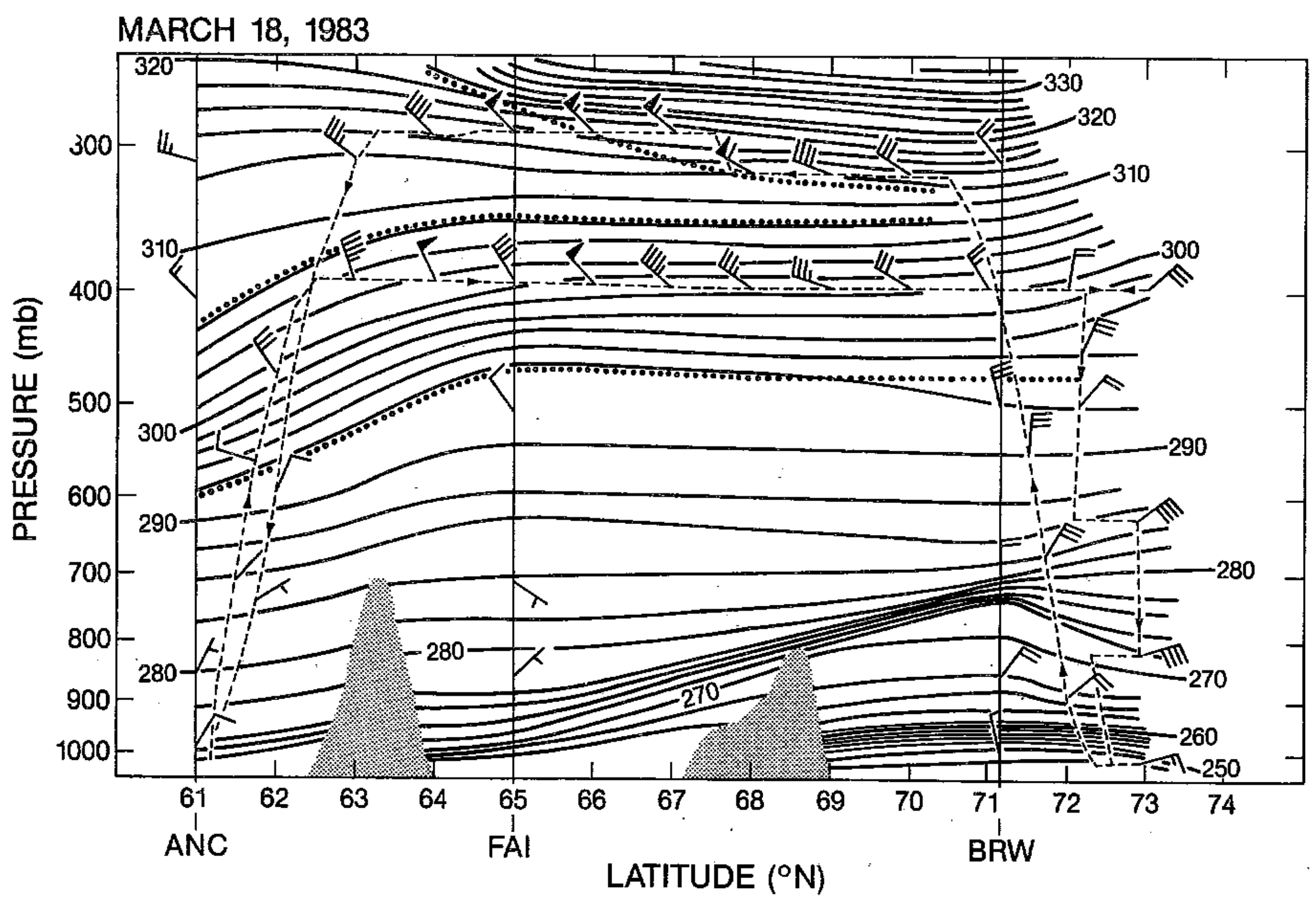

Fig. 20: Latitude-altitude cross section of potential temperature (K) and wind (kt), March 17/18, 1983. The tropopause and the stable layer are indicated by the dotted lines. The aircraft flight track is indicated by the thin broken lines.

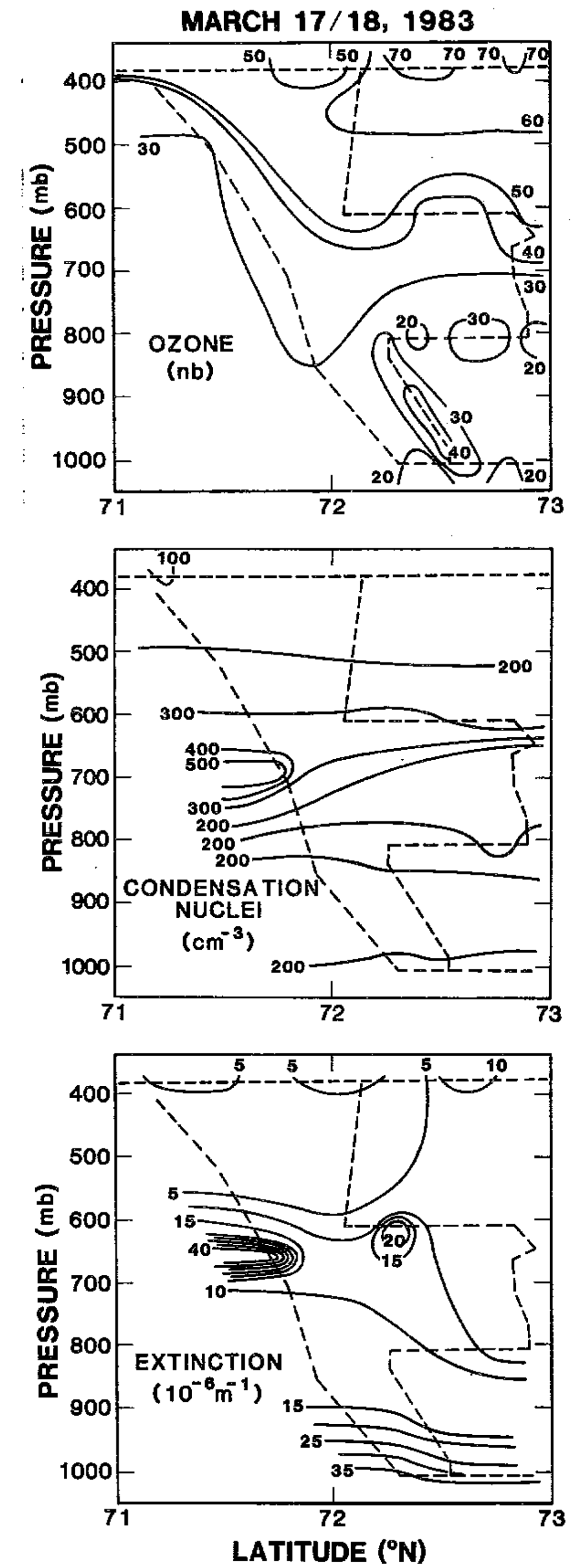

Fig. 21: Horizontal and vertical distribution of ozone and CN concentrations and of extinction coefficients (σ_{sp}) within the Arctic anticyclone, March 17/18, 1983. The aircraft flight track is indicated by the broken lines.

4.5 Vertical and Horizontal Distribution of Condensation Nuceli, Extinction Coefficient, Ozone and Relative Humidity near Barrow

Figure 21 presents the horizontal and vertical distribution of ozone and CN concentrations, and extinction coefficient, over the ice north of Barrow. North of 72 ° N and above 720 mb the aircraft was flying within the Arctic anticyclone and its subsiding air. Ozone concentrations measured within the anticyclonic air mass range from 50 to 70 nb, whereas outside the anticyclone within the tropospheric Arctic air, ozone concentrations vary between 20 and 30 nb only. CN concentrations within the anticyclone range from 100 to 300 cm^{-3}, whereas CN concentrations in tropospheric air are slightly higher. Extinction coefficients reflect the distribution of CN concentration, and values measured inside the anticyclonic air are some of the lowest recorded during the entire AGASP project. We note, that the enhanced concentrations of ozone are accompanied by low CN counts when associated with subsidence, in contrast to stratospheric air in a tropopause folding event in the same area (Raatz et al., 1985a).

5. AGASP Flight No. 5 (March 21, 1983)

5.1 Mission Type

Leaving from Anchorage, AK, the aircraft crossed the interior of Alaska near direction of Barter Island, AK, and continued across the frozen Beaufort Sea in the direction of Prince Patrick Island, a few hundred miles off the Arctic coast. At about 82 ° N, 100 ° W the aircraft turned southeastward and headed for Thule Air Force Base. It was the purpose of this flight to obtain long horizontal flight tracks within the Arctic air mass. The horizontal projection of the flight track is given in Figure 22. Total flight time was 8 h 15 min.

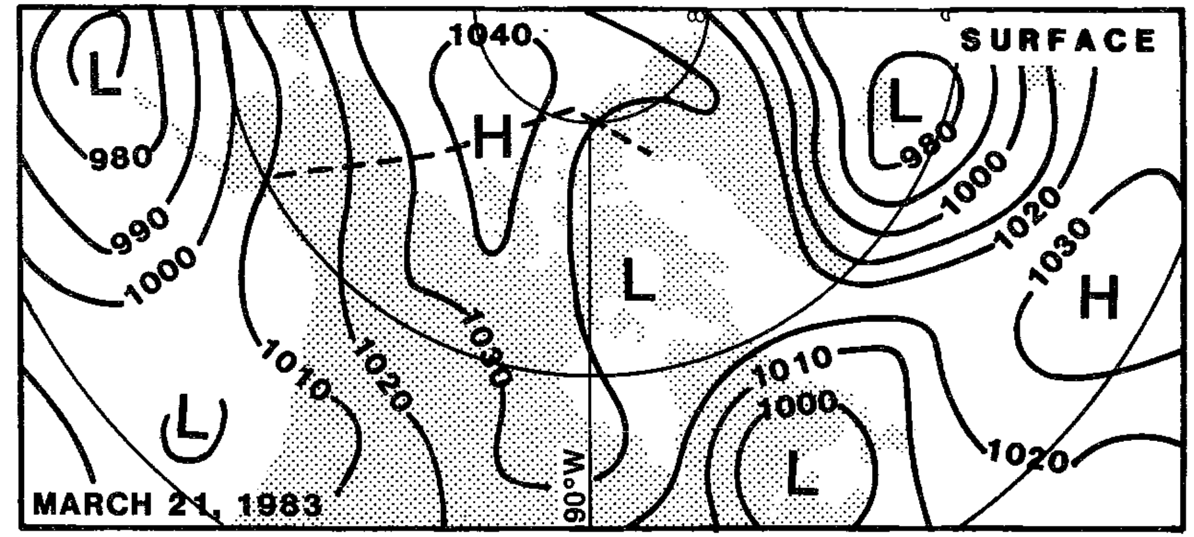

Fig. 22: The surface pressure (mb) distribution and approximate flight track (broken line) over the western Arctic, March 21, 1983, 0000 GMT.

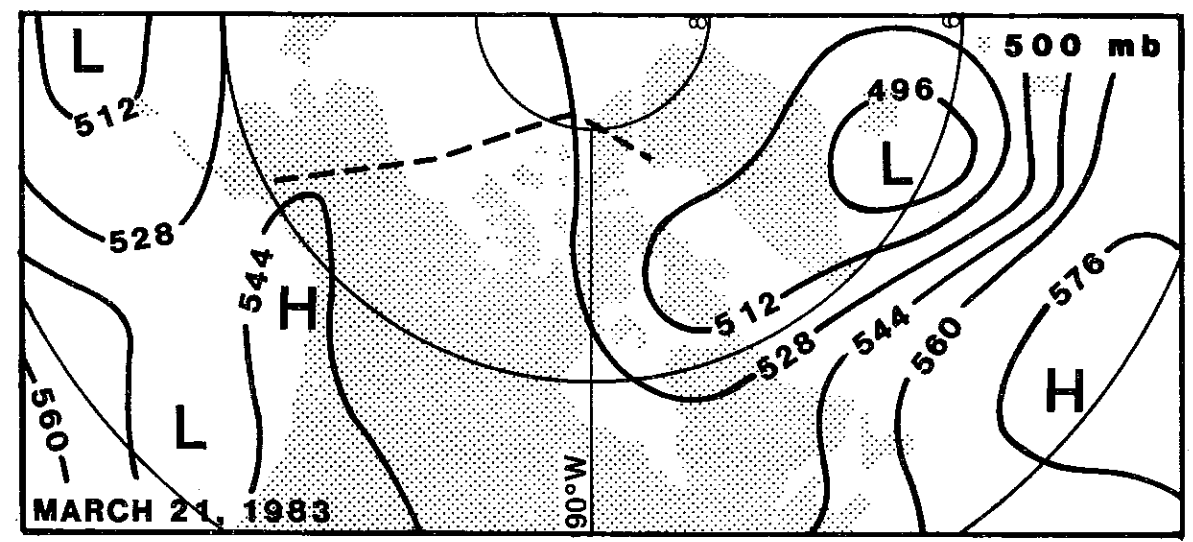

Fig. 23: The 500-mb pressure height (geopotential decameters) distribution and approximate flight track (broken line) over the western Arctic, March 21, 1983. 0000 GMT.

5.2 Synoptic Situation

The near-surface pressure distribution (Fig. 22) was characterized by an anticyclone over the Beaufort Sea. To the west, the combination of the Aleutian cyclone and the anticyclone created a frontal zone across interior Alaska; to the east, the combination of the Icelandic cyclone and the anticyclone created a frontal zone along Greenland's east coast. At 500 mb (Fig. 23) the pressure gradients over Canada's Arctic were weak. Both surface cyclones were developed at 500 mb; the surface anticyclone was supported by a weak high-pressure ridge.

5.3 Flight Log

11:45	take off, Anchorage, AK
11:45-12:09	ascent within Pacific air
12:09-12:42	horizontal track at 485 mb, upper tropospheric (Arctic) air
12:42-13:42	horizontal track at 485 mb, stratospheric air
13:42-14:26	descent within Arctic air down to surface (Raatz et al., 1985c)
14:26-14:47	ascent within Arctic air
14:30	sunrise, haze bands visible, amorphous in antisolar direction, reddish brown in solar direction, no clouds, haze remained visible continuously throughout the flight
14:47-17:20	horizontal track at 845 mb within Arctic air
16:21	haze appears thicker, no clouds
17:10	very thick haze below aircraft (maybe within surface inversion), no clouds
17:20-17:25	ascent
17:25-18:31	horizontal flight track at 573 mb within Arctic air
18:10	front passage (Raatz et al., 1985c)
18:15	haze below aircraft, thinner as before, no clouds
18:31-18:35	descent
18:35-19:00	horizontal flight track at 673 mb within Arctic air
18:45	frontal passage (Raatz et al., 1985c)
19:00-19:58	descent
19:15	low-level haze, 1/8 St
19:58	Thule Air Force Base, Greenland

5.4 Atmospheric Cross Section

A longitude-altitude cross section of potential temperature (Figure 24) was constructed along the flight track on the basis of radiosonde data obtained over Anchorage (ANC), Fairbanks (FAI), Barter Island (BTI), Mould Bay (YMD), Resolute (YRB), Eureka (WEU), and Thule (THL), and data recorded by the aircraft along its flight track. No dropsondes were released.

While flying northward at 483 mb over Alaska, the aircraft briefly penetrated a tropopause fold associated with the frontal zone (Raatz et al., 1985c). North of Barter Island the aircraft descended and began a horizontal track at 845 mb (above the surface inversion layer) across the Beaufort Sea. Another long horizontal track was flown at 573 mb. Both horizontal tracks were flown within a homogeneous Arctic air mass. No frontal boundaries were crossed. Two weak frontal zones were noticed in the vicinity of Thule (Raatz et al., 1985c).

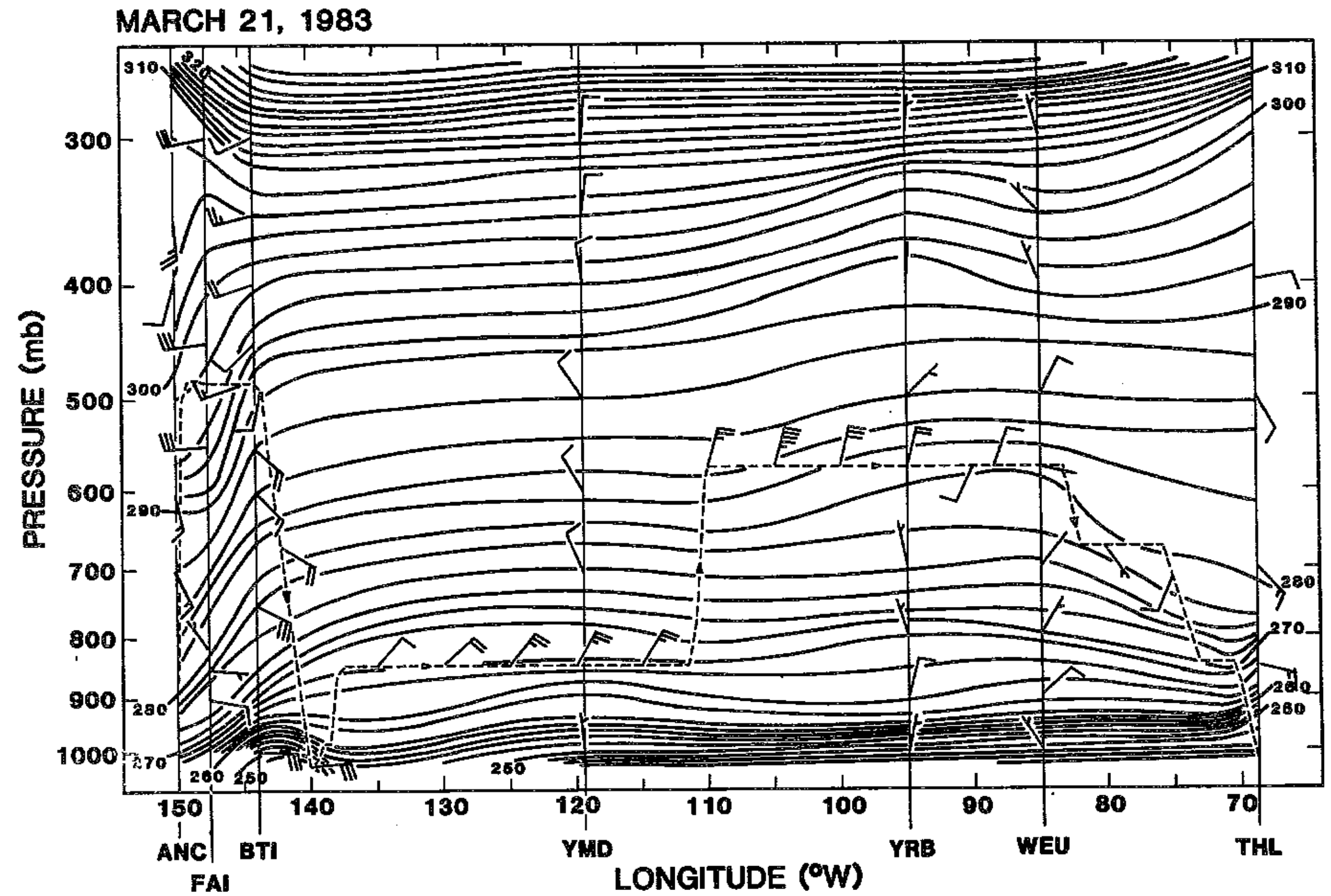

Fig. 24: Longitude-altitude cross section of potential temperature (K) and wind (kt) March 21, 1983. The aircraft flight track is indicated by the broken line.

5.5 Horizontal Variability Across the Arctic Anticyclone

The horizontal flight track at 845 mb was obtained between 1449 (74.0 °N, 137.74 °W) and 1718 GMT (80.89 °N, 111.82 °W). This flight track describes the conditions inside and along the eastern flank of the Arctic anticyclone. The flight level is above the boundary layer and conditions described are therefore characteristic of the middle troposphere.

From Figure 25, note that the anticyclone is characterized by low wind speeds that gradually increase as the aircraft moves farther to the east. The anticyclone appears to have on the average lower σ_{sp} values than does its eastern flank. CN concentrations within the anticyclone vary between 150 and 500 cm^{-3}, but appear to be slightly lower there than outside. Ozone concentrations vary slightly, but do not show a change when moving from the inside to the outside. Wind direction gradually changes from 45° to 25°. Air temperatures do not change. Dew point shows variability; however, its variability cannot always be related to variability in the other parameters displayed.

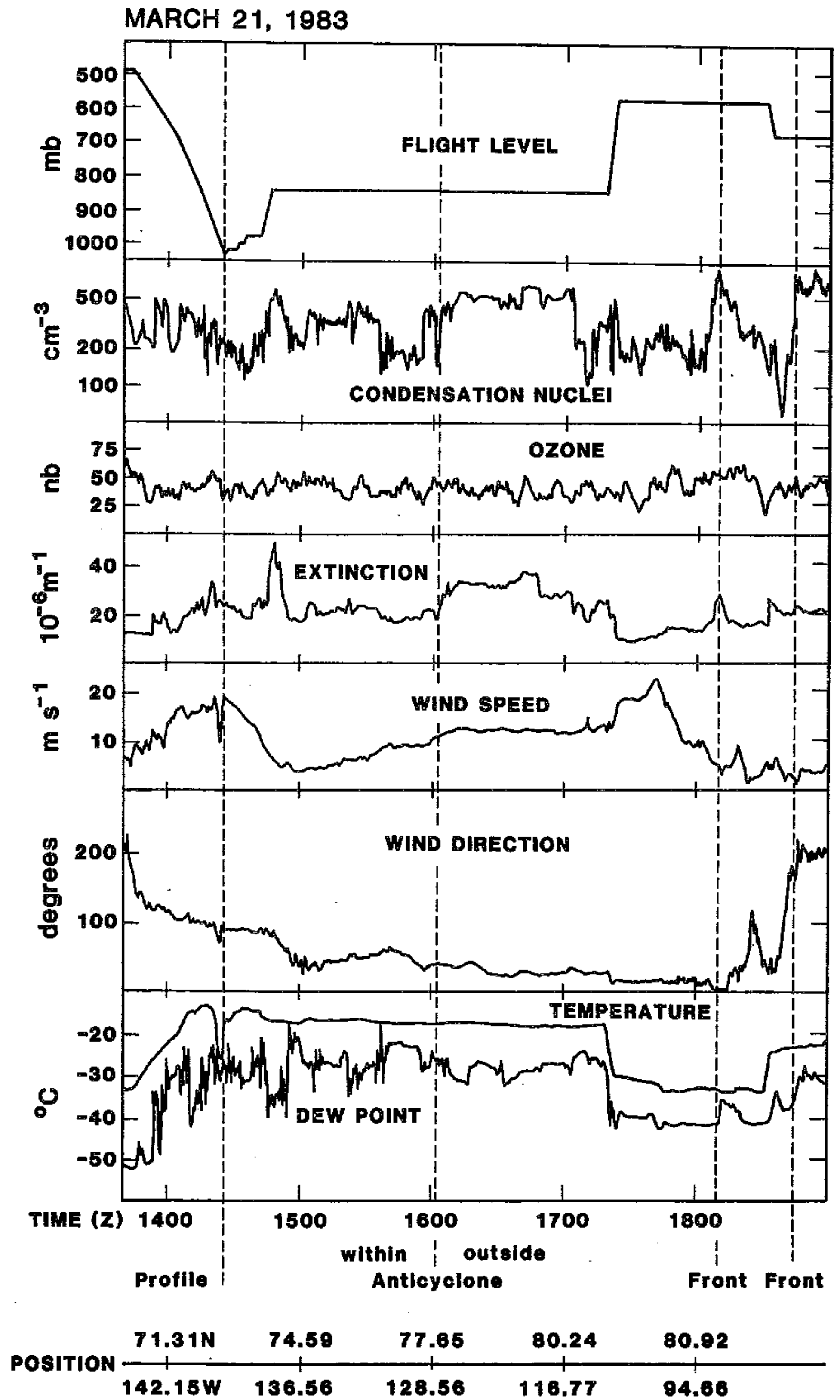

Fig. 25: Time series taken between 1340 (69.90 °N, 143.85 °W) and 1900 GMT (78.33 °N, 75.67 °W) on March 21, 1983.

6. AGASP Flight No. 6 (March 23, 1983)

6.1 Mission Type

The aircraft flew from Thule, Greenland, along the west coast toward the southern tip of Greenland. It was the purpose of the flight to penetrate and characterize a tropopause fold (Shapiro et al., 1984). The horizontal flight track is given in Figure 26. Total flight time was 7 h 25 min.

6.2 Synoptic Situation

The upper tropospheric circulation (500 mb) was characterized by a cyclonic pressure system just south of Thule and a high-pressure ridge over the North Atlantic (Figure 26). Hence, a strong baroclinic zone developed just across the southern tip of Greenland.

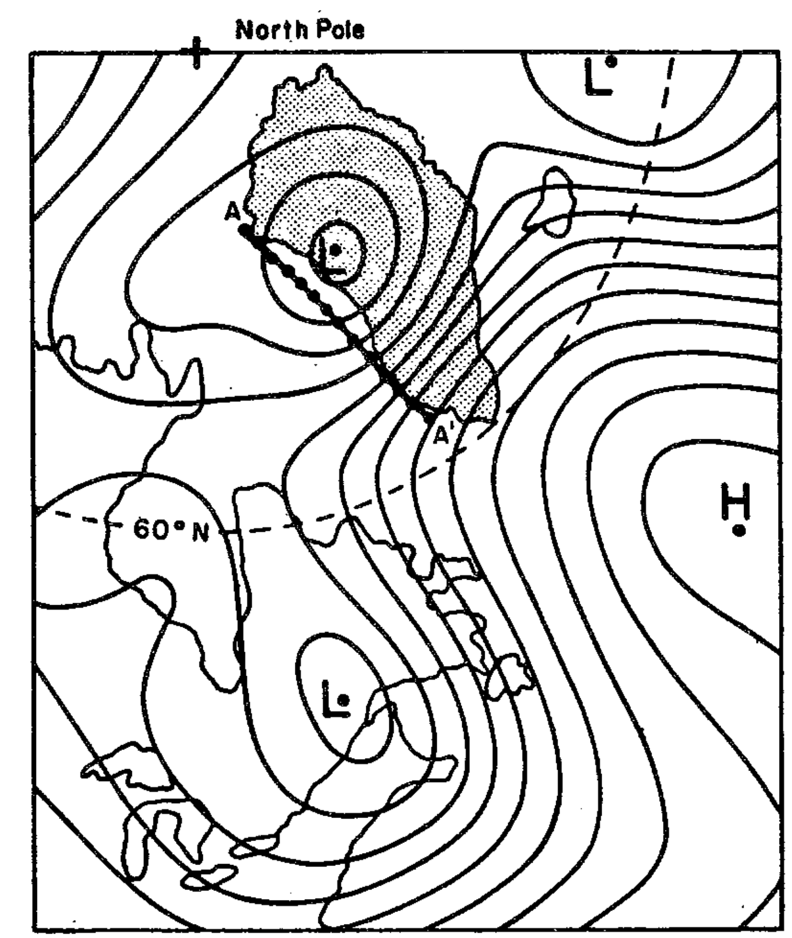

Fig. 26: The 500-mb pressure pattern near Greenland, March 24, 1983, 0000 GMT. The flight track was along the vector AA′ and return (Shapiro et al., 1984).

6.3 Flight Log

12:50	take off, whitish haze observed throughout the flight
12:50-13:10	ascent, Arctic air
13:10-14:07	horizontal track at 484-490 mb, upper tropospheric (Arctic) air
13:10-14:25	3/8-7/8 St
14:07-15:30	horizontal track at 484-490 mb, stratospheric air
14:10-15:00	haze appears thicker, no horizon visible
14:30	light turbulence
14:55	large cracks in the ice, open water
15:20-16:20	4/8-8/8 St, 1/8-8/8 Ci
15:30-15:39	descent, upper tropospheric (Atlantic) air
15:37	some haze left, approaching southernmost boundary of Arctic air mass
15:39-16:00	horizontal track at 600 mb within Atlantic air
16:00-16:25	ascent within upper tropospheric air
16:25-16:38	horizontal track at 393 mb in upper tropospheric air
16:38-17:02	horizontal track at 393 mb in stratospheric air
17:02-17:17	ascent within stratospheric air
17:17-19:54	horizontal track at 316 mb in stratospheric air
19:54-20:26	final descent

6.4 Atmospheric Cross Section

A latitude-altitude cross section of potential temperature and wind speed (Figure 27) was constructed along the flight track on the basis of radiosonde data obtained over Thule, Sondrestrom, and Narssarssuaq; data from seven dropsondes released by the aircraft; and data recorded by the aircraft along its flight track.

The cross section is determined by two folds. One fold was located at about 74 ° N and was associated with a weak easterly jet. The other fold was located at about 66 ° N and was associated with a strong westerly jet. The boundary between Arctic and Atlantic air, was probably to the south of this jet as suggested by the decrease in haze intensity.

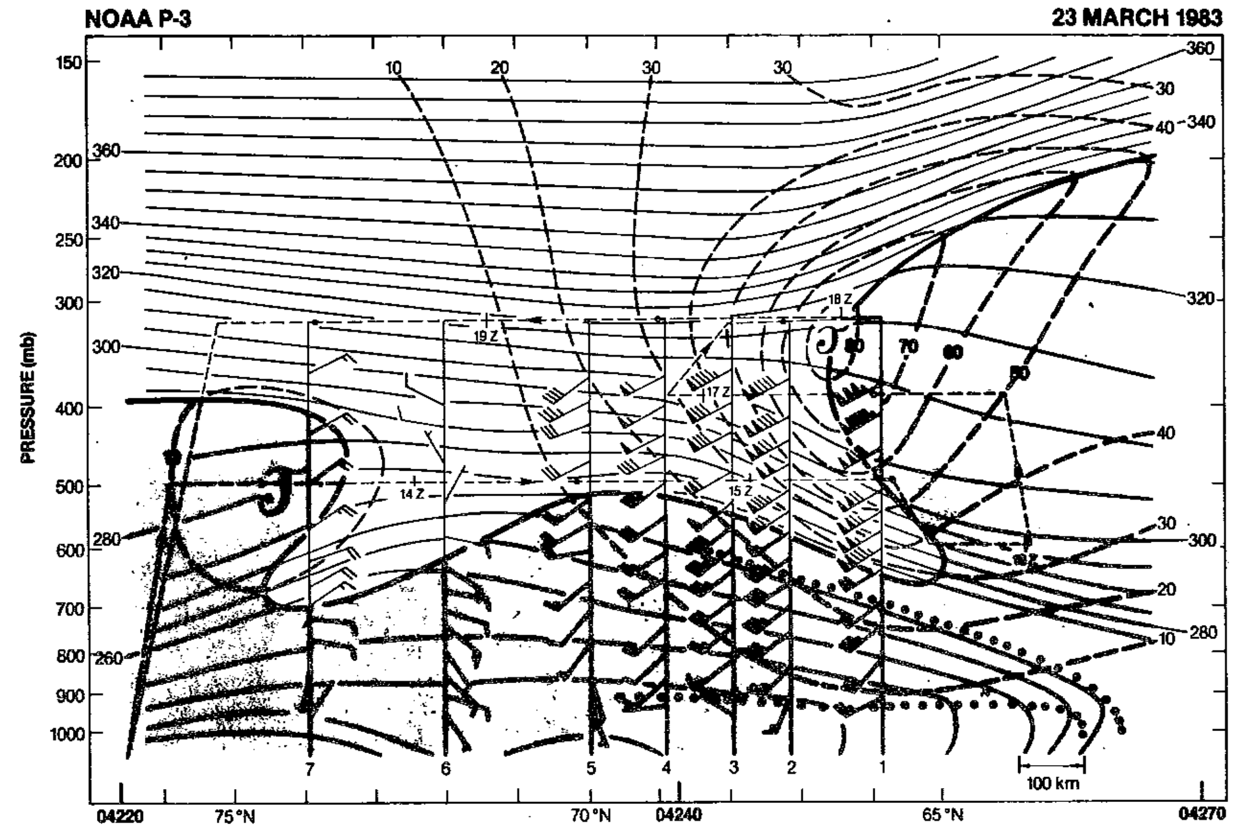

Fig. 27: Latitude-altitude cross section of potential temperature (K, solid isolines) and wind speed (m/s, broken isolines) March 23, 1983, (Shapiro et al., 1984). The aircraft flight track is indicated by the thin broken line.

7. AGASP Flight No. 7 (March 28, 1983)

7.1 Mission Type

The aircraft flew northward from Thule, Greenland, and obtained a vertical profile while descending in the vicinity of Alert, N.W.T. The aircraft continued to the North Pole and then crossed the Norwegian Arctic along the eastern side of Svalbard before reaching Bodo, Norway. The horizontal flight track is given in Figure 28. Total flight time was 9 h.

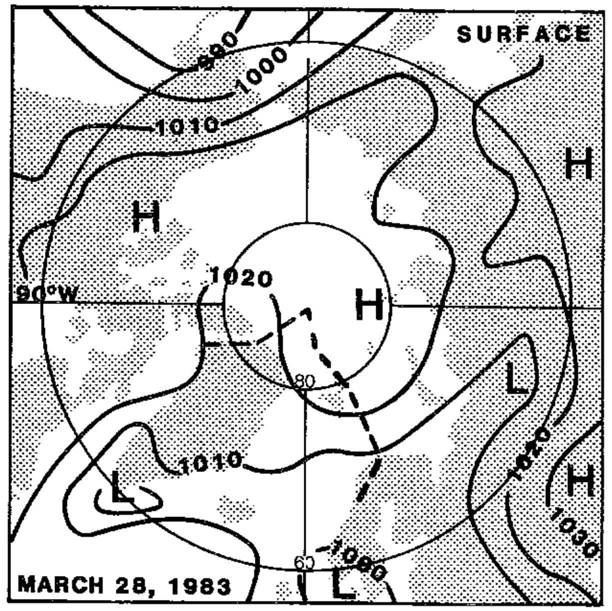

Fig. 28: The surface pressure (mb) distribution and flight track (broken line) over the Arctic, March 28, 1983, 0000 GMT.

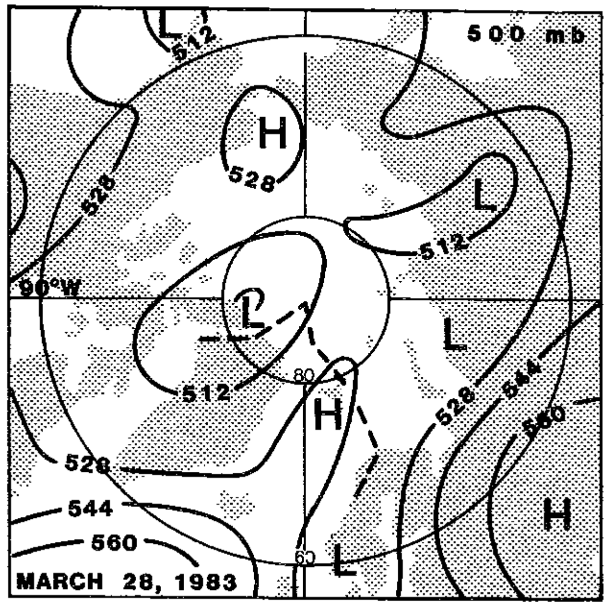

Fig. 29: The 500-mb pressure height (geopotential decameters) distribution and flight track (broken line) over the Arctic, March 28, 1983, 0000 GMT.

7.2 Synoptic Situation

The near-surface pressure distribution (Figure 28) was characterized by a large anticyclonic system dominating the central Arctic region. A large cyclonic system was located over the North Atlantic between southern Greenland and Novaya Zemlya. This resulted in an east to west surface flow over the Norwegian Arctic.

The upper tropospheric circulation (500 mb) was characterized by the Baffin Island cyclone over Queen Elizabeth Islands and a high-pressure ridge extending from Iceland to Svalbard (Fig. 29). A low-pressure trough was located over Scandinavia.

7.3 Flight Log

13:16	take off, Thule, Greenland
13:16-13:38	ascent within Arctic air
13:22	dark haze bands at horizon in direction of sun, no clouds
13:38-14:34	horizontal track at 408-413 mb, upper tropospheric (Arctic) air
13:50	haze, no horizon visible, haze and snow blend in
14:00	thick haze, no clouds
14:10	thick haze, 1/8 St
14:20	aircraft above haze, 4/8 St
14:20	thick haze, 1/8 Sc, mountain clouds
14:35-15:33	descent (Raatz et al., 1985c; Hoff and Trivett, 1984) within Arctic air
14:50	haze at horizon, a good vertical visibility to sea ice
15:20	turbulence
15:32	haze aloft, clear interstice between sea ice and haze, no clouds
15:33-15:36	ascent within Arctic air
15:36-17:25	horizontal track at 846 mb within Arctic air
15:42	aircraft in thick haze, poor horizontal visibility
17:10	amorphous haze at horizon, no clouds, good vertical visibility downward
17:25-17:29	descent
17:29-17:31	horizontal track at 995 mb within Arctic air
17:31-17:35	ascent
17:35-18:01	horizontal track at 843 mb within Arctic air and frontal passage
18:00	patches of low level haze, 2/8 Ci
18:01-19:12	horizontal flight track at 843 mb within moist transport zone (Raatz et al., 1985c)
18:10	aircraft in this cloud, 2/8 Ci above
18:25-18:40	8/8 Sc below, 4/8 Ci above aircraft
19:00	3/8 Ci aloft
19:10	2/8 Ci, hazy, sunset
19:12-19:16	horizontal track at 843 mb within dry air
19:16-19:34	ascent within Atlantic air
19:34-20:36	horizontal track at 343-347 mb within upper tropospheric air
20:36-21:54	horizontal track at 343-347 mb within stratospheric air (Raatz et al., 1985c)
23:54-21:58	descent within stratospheric air
21:58-22:26	descent within tropospheric air, Bodo, Norway

7.4 Atmospheric Cross Section

A latitude-altitude cross section of potential temperature and water vapor mixing ratio (Figure 30) was constructed along the flight track on the basis of radiosonde data obtained over Thule (THL), Alert (YLT), Barentsburg (BRG), and Bodo (BOD); data from three dropwindsondes released from the aircraft at the North Pole, at 77 °N, and at 73 °N over the Norwegian Arctic; and data recorded by the aircraft along its flight track.

Flying from Thule to Alert, the aircraft moved toward the cold Baffin Island cyclone, as indicated by the rising isopleths of potential temperature. Before reaching the tropopause, the aircraft started a descent (Raatz et al., 1985c) and thus missed a penetration of the large tropospheric baroclinic zone (Arctic front) at upper and intermediate levels. However, the baroclinic zone was penetrated at the 843-mb level. It is only speculation that this baroclinic zone actually reached from the surface up into the stratosphere. Just to the south of the front at 843 mb there was a zone of increased water vapor mixing ratios (moist transport zone) followed by a region of dry air (Raatz et al., 1985c). The aircraft then ascended to the upper troposphere and penetrated a tropopause fold before its final descent to Bodo (Raatz et al., 1985c). Between Barentsburg and Bodo a moist marine boundary layer was present starting at the ice edge and rising in height toward the south.

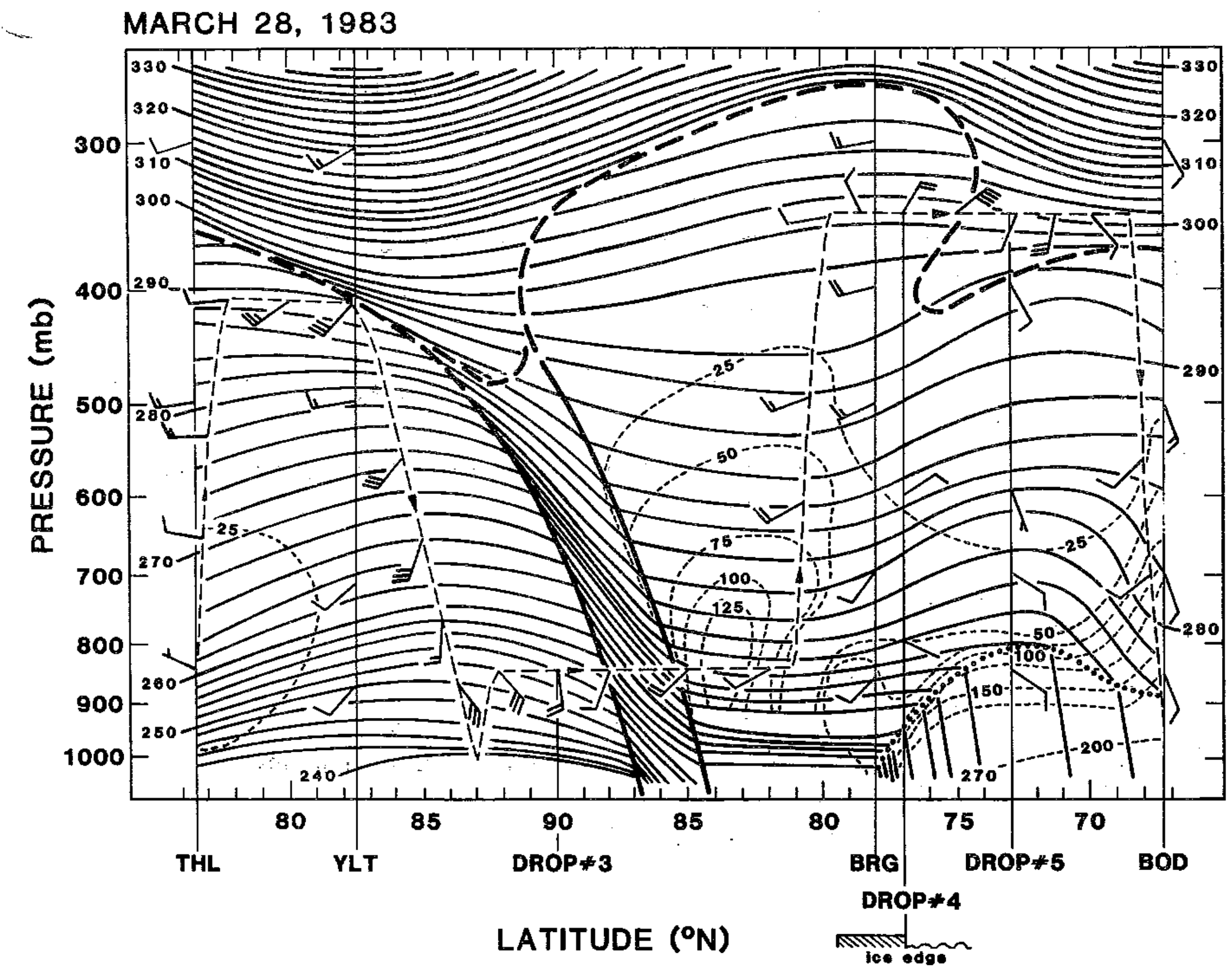

Fig. 30: Latitude-altitude cross section of potential temperature (K, solid isolines), water vapor mixing ratio ($\times 10^{-2}$ g/kg, broken isolines), and wind speed (kt) March 28, 1983. The aircraft flight track is indicated by the thin broken line.

7.5 Characteristics of Penetrating a Tropopause Fold Over Norway

The time series presented in Figure 31 was taken between 1941 (79.02 °N, 24.99 °E) and 2150 GMT (68.71 °N, 17.26 °E) on March 28, 1983, at a flight altitude of 346 mb.

The main feature of this time series is the intrusion of stratospheric air through a tropopause fold located between 74.01 °N, 24.93 °E (2035 GMT) and 71.80 °N, 24.92 °E (2100 GMT). Between 2000 and 2040 GMT a wind speed maximum of 20 ms^{-1} is observed followed by a wind speed minimum associated with a change in wind direction from west to northeast. Another wind speed maximum of 20 ms^{-1} is evident between 2100 and 2120 GMT. The intrusion of stratospheric air is characterized by the presence of a dry air mass, slightly warmer temperatures, a decrease in CN concentrations, and a strong increase in ozone concentrations exhibiting a double peak of 70 nb.

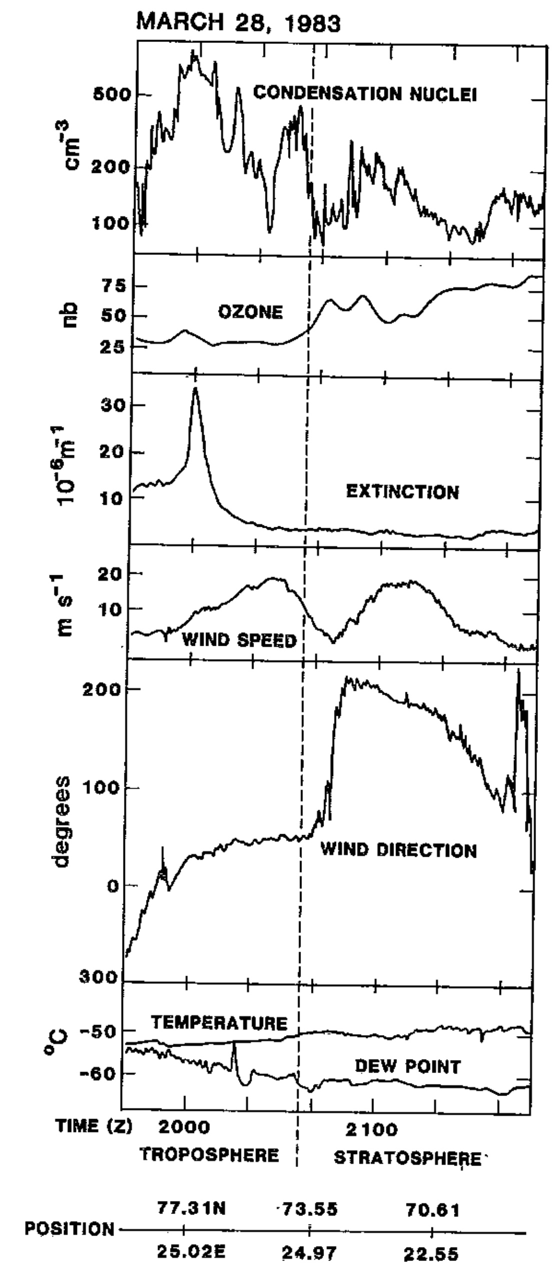

Fig. 31: Time series of aerosol and meteorological parameters taken between 1941 (79.02 °N, 24.99 °E) and 2150 GMT (68.71 °N, 17.26 °E) on March 28, 1983. at a flight altitude of 346 mb as the aircraft penetrated a tropopause fold.

8. AGASP Flight No. 8 (March 31, 1983)

8.1 Mission Type

It was the objective of the flight to obtain both horizontal tracks and vertical profiles within haze over the Norwegian Arctic. The aircraft flew from Bodo, Norway, northward along the Norwegian coast and then approximately along the 25 °E longitude as far north as 81 °N, 15 °E. The aircraft then returned southward along a southeasterly track followed by a southwesterly track before returning to Bodo. The horizontal flight track is given in Figure 32. Total flight time was 10 h.

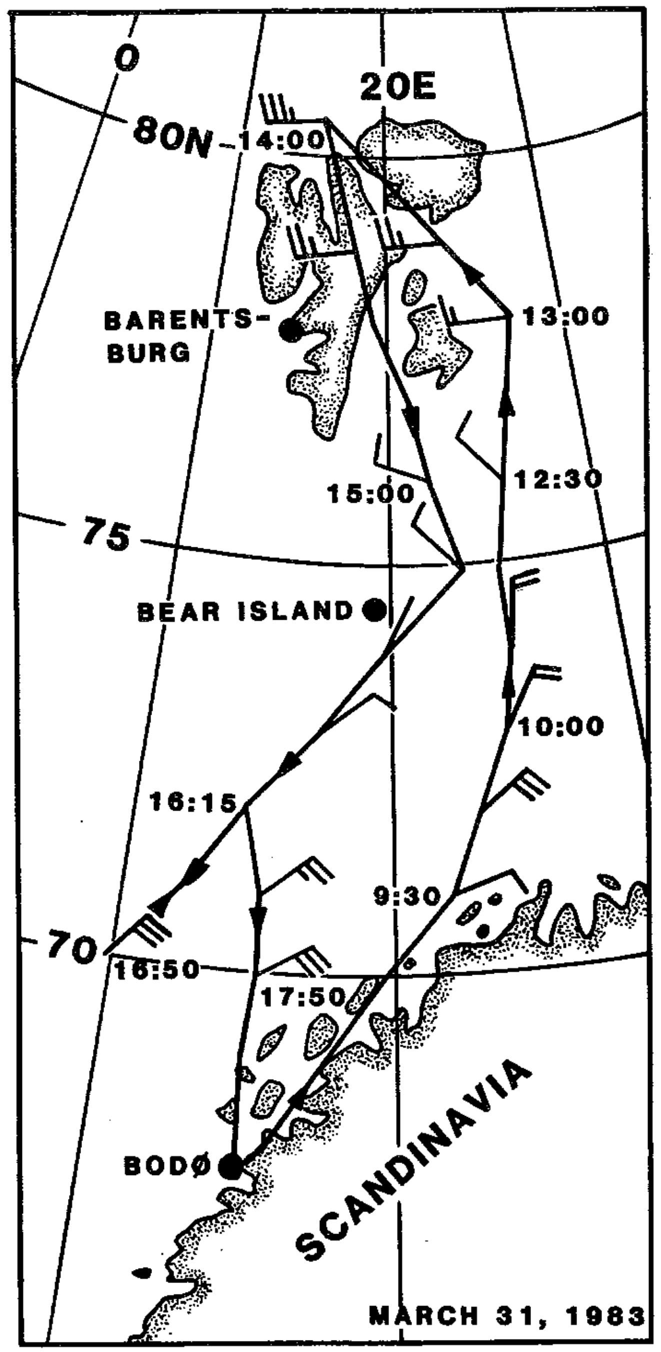

Fig. 32: **Horizontal projection of the aircraft's flight track over the Norwegian Arctic, March 31, 1983. The wind speeds are in kt.**

8.2 Synoptic Situation

The near-surface pressure distribution (Figure 33) was characterized by a cyclonic pressure system over Scotland and an anticyclone over northern Greenland. Hence, the Norwegian Arctic was located within the confluence zone of Arctic air from the north, polar continental air from the east, and maritime air from the south. At upper tropospheric levels (700 mb) the atmospheric circulation was characterized by a high-pressure ridge over the North Atlantic extending into the Norwegian Arctic and by a trough over Great Britain and Scandinavia (Fig. 34). The Arctic north of Svalbard was under cyclonic influence.

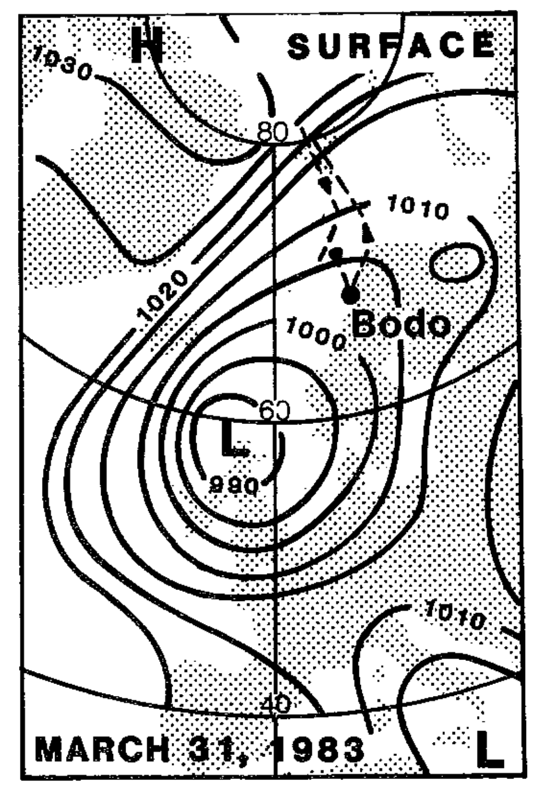

Fig. 33: The surface pressure (mb) distribution over the Norwegian Arctic, March 31, 1983, 0000 GMT.

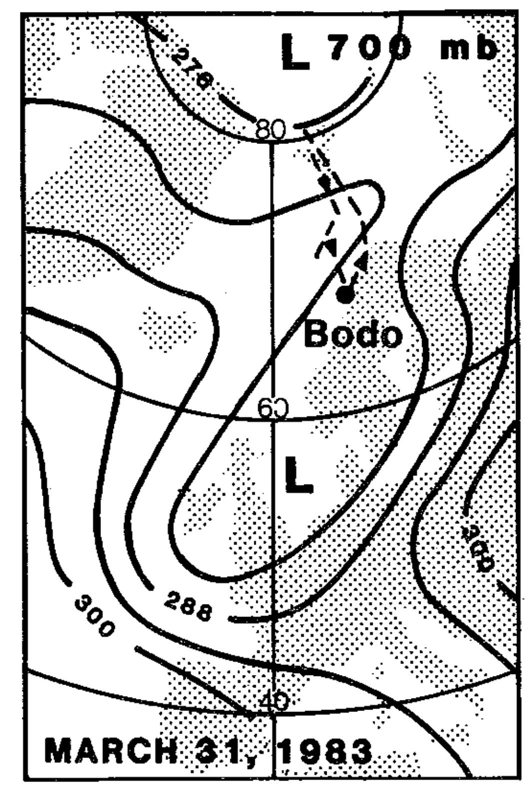

Fig. 34: The 700-mb pressure height (geopotential decameters) distribution over the Norwegian Arctic, March 31, 1983, 0000 GMT.

8.3 Flight Log

8:27	take off
8:27-8:55	ascent
8:45	haze bands aloft, whitish horizon
8:55-10:31	horizontal track at 408-412 mb within upper tropospheric (maritime) air
9:00	haze below, at, and above flight level
9:20-10:30	4/8-7/8 Cu cloud streets over open water, haze above clouds, below, at, and above aircraft
10:31-10:51	descent (Raatz et al., 1985d; Raatz and Schnell, 1984)
10:51-10:59	horizontal track at 622 mb
10:59-11:18	descent (Raatz et al., 1985d; Raatz and Schnell, 1984)
11:18-11:30	horizontal track at 813 mb
11:30-11:43	descent (Raatz et al., 1985d; Raatz and Schnell, 1984)
11:43-11:56	horizontal track at 999-1006 mb within marine boundary layer
11:56-12:07	ascent
12:07-12:25	horizontal track at 597 mb
12:25-12:32	descent
12:32-13:15	horizontal track at 622 mb within continental polar air (Raatz et al., 1985d; Raatz and Schnell, 1984)
12:50	little/no haze
13:10-14:20	no haze, 4/8-8/8 Sc, 3/8-7/8 Ci, subsuns observed
13:15-14:15	horizontal track at 622 mb within Arctic air (Raatz et al., 1985d; Raatz and Schnell, 1984)
14:15-15:17	horizontal track at 622 mb within continental polar air (Raatz et al., 1985d; Raatz and Schnell, 1984)
14:50-15:10	3/8-6/8 Sc, 1/8-4/8 Ci, haze bands visible again
15:10-15:50	in haze, 3/8-6/8 Sc
15:17-15:33	descent
15:33-16:08	horizontal track at 754 mb
16:07-17:40	6/8-7/8 Cu cloud streets, haze bands
16:08-16:14	ascent
16:14-17:26	horizontal track at 684 mb
17:26-17:37	ascent
17:37-18:05	horizontal tract at 376 mb within upper tropospheric air
18:05-18:30	final descent

8.4 Atmospheric Cross Section

A latitude-altitude cross section of potential temperature and water vapor mixing ratio (Figure 35) was constructed along the flight track on the basis of radiosonde data obtained over Bodo (BOD) and Barentsburg (BRG), and data recorded by the aircraft along its flight track. No dropwindsondes were released.

The lower troposphere is characterized by a marine boundary layer, whose height rises as one moves southward away from the ice edge. Between 70° and 74° N and above the marine boundary layer there is a dry air mass in which most of the haze was concentrated (Raatz et al., 1985d).

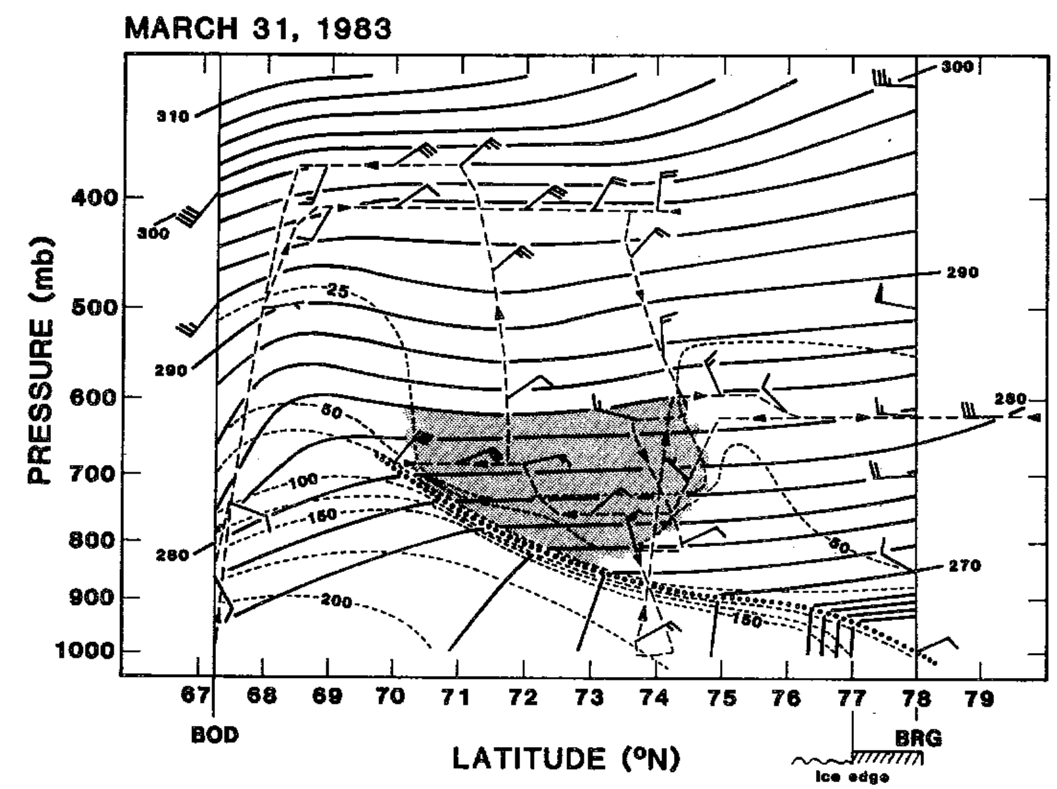

Fig. 35: Latitude-altitude cross section of potential temperature (K, solid isolines), water vapor mixing ratio ($\times 10^{-2}$ g/kg, broken isolines), and wind speed (kt), March 31, 1983. The aircraft flight track is indicated by the broken line. The top of the marine boundary layer is indicated by the dotted line.

8.5 Evidence of an Arctic Aerosol Front

A so-called Arctic aerosol front was discovered at 79 ° N east of Svalbard while the aircraft was flying at a constant level of 620 mb (Raatz and Schnell, 1984). Figure 36 presents a time series of aerosol and meteorological parameters measured by the aircraft between 1200 and 1520 GMT.

Between 1220 and 1315 GMT, while the aircraft was northbound, CN concentrations averaged around 450 cm^{-3}. They abruptly decreased to a mean value of 80 cm^{-3} after 1320 GMT and remained at this low level until 1442 GMT. This decrease in CN concentrations was accompanied by the disappearance of visual haze and by extremely improved horizontal and vertical visibilities. At 80.39 ° N, 154.51 ° E (1350 GMT) the aircraft turned south and 20 min later reentered the haze-laden air mass at 1410 GMT, whereupon the CN concentrations rose again to the former 400-500 cm^{-3} level. A similar, but less dramatic variation is seen in the σ_{sp} data. Although the change in air mass characteristics across the front was striking in terms of changes in CN concentrations and σ_{sp}, changes in the meteorological parameters were less obvious .

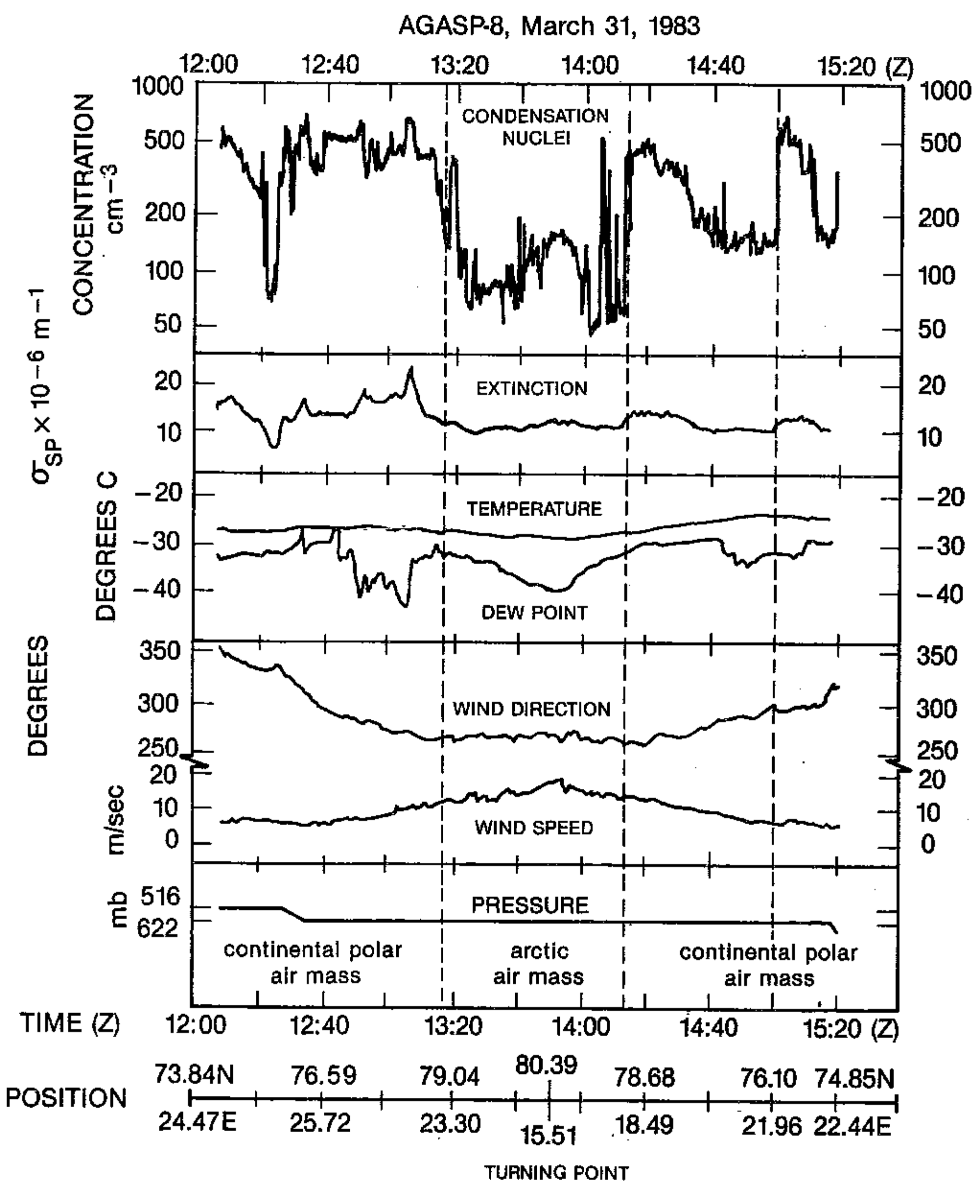

Fig. 36: Time series of aerosol and meteorological parameters for March 31, 1983, as the aircraft passed through an Arctic aerosol front at 620 mb (Raatz and Schnell, 1984).

9. AGASP Flight No. 9 (April 4, 1983)

9.1 Mission Type

The aircraft flew from Bodo, Norway, northwestward to 70 ° N, northeastward up to 25 ° E, and northward along 25 ° E longitude, east of Svalbard, up to 79 ° N. The aircraft then returned south back to Bodo. The horizontal projection of the flight track is given in Figure 37. During the mission a vertical profile was obtained at 70 ° N and several horizontal runs were obtained at low tropospheric levels. Total flight time was 10 h.

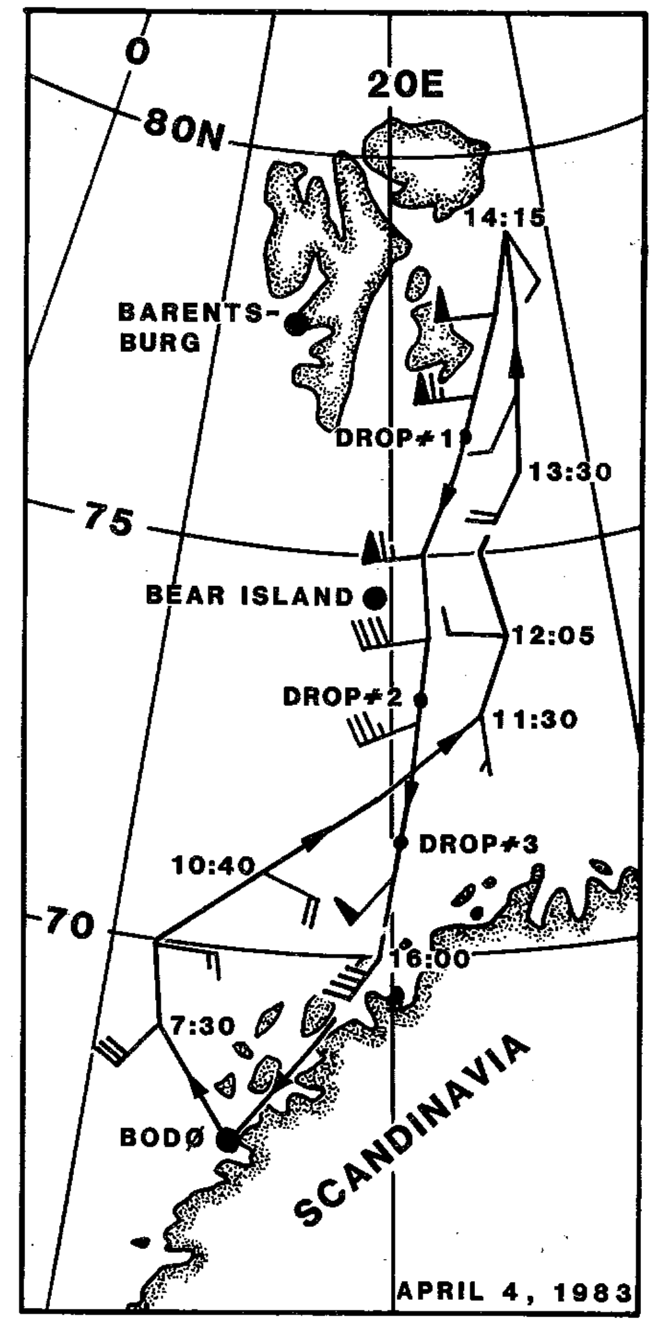

Fig. 37: Horizontal projection of the aircraft's flight track over the Norwegian Arctic, April 4, 1983. Wind speeds are in kt.

9.2 Synoptic Situation

The surface pressure (mb) distribution was characterized by a large cyclonic system between Greenland and East Europe (Fig. 38). Anticyclones were located to the north over the inner Arctic region and to the east of the Ural Mountains. This resulted in a near-surface flow from the east-northeast across the Norwegian Arctic toward the west. This synoptic situation was similar to the one observed on March 31, except that the cyclone over Great Britain has weakened and lost some of its influence over the Norwegian Arctic. The flow from the Taymyr Peninsula into the Norwegian Arctic has weakened as well.

The upper tropospheric circulation (700 mb) was characterized by a low-pressure system over the Norwegian Sea and a weak high-pressure ridge across the Norwegian Arctic. At 500 mb a zone of increased pressure gradients between midlatitude air and Arctic air had formed over Svalbard.

9.3 Flight Log

6:40-7:30	ascent
7:30-8:05	horizontal track at 426 mb within upper tropospheric air
7:34-8:06	some Cu, St
7:42	entering thin Ci deck
8:05-9:16	descent (Raatz et al., 1985d; Raatz and Schnell, 1984)
8:06	haze appears visible and remains present throughout the flight
9:16-10:06	horizontal track at 997-1003 mb within marine boundary layer
9:17	bumpy, seasalt in layer
10:06-10:19	ascent
10:10-12:21	very hazy
10:16-10:55	Cu, Ci clouds
10:19-11:27	horizontal track at 768 mb within polluted continental air (Raatz et al., 1985d)
11:27-11:33	descent
11:33-12:01	horizontal track at 1008-1014 mb within marine boundary layer
12:01-12:06	ascent
12:06-12:24	horizontal track at 764-766 mb
12:13	frontal passage as indicated by wind shift
12:24-12:40	descent
12:33	ice edge
12:40-14:14	horizontal track at 1000-1014 mb
14:10-16:10	very hazy
14:14-14:42	ascent
14:30	strong brown cloud
14:42-16:35	horizontal track at 327-332 mb
15:55-16:45	Cu, St
16:35-17:04	final descent

9.4 Atmospheric Cross Section

A latitude-altitude cross section of potential temperature and water vapor mixing ratio (Figure 38) was constructed along the flight track on the basis of radiosonde data obtained over Bodo (BOD) and Barentsburg (BRG); data from three dropwindsondes released at about 76.50 ° N, 73.33 ° N, and 71.60 ° N; and data recorded by the aircraft along its flight track.

The cross section is very similar to the one constructed for March 31, except that the overall temperature gradient between midlatitudes and the polar region has increased. Again, in the lower troposphere a marine boundary layer is present, its height rising as one moves southward away from the ice edge. A dry air mass is present between 69 and 74 ° N, and above the marine boundary layer. Strongest haze was observed when the aircraft was within this dry air (Raatz et al., 1985d).

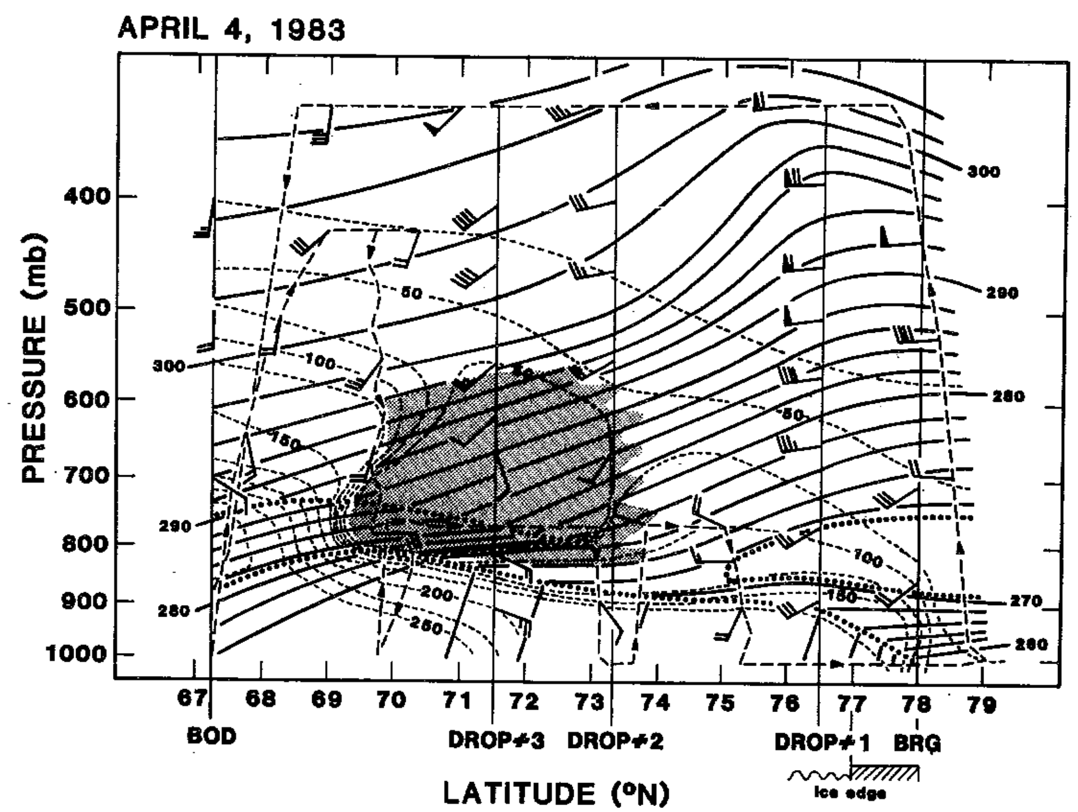

Fig. 38: Latitude-altitude cross section of potential temperature (K, solid isolines) and water vapor mixing ratio ($\times 10^{-2}$ g/kg, broken isolines) and wind speeds (kt), April 4, 1983. The aircraft flight track is indicated by the broken line. The top of the marine boundary layer and the boundaries of stable layers are indicated by the dotted lines.

10. AGASP Flight No. 10 (April 5, 1983)

10.1 Mission Type

The aircraft flew northwestward from Bodo, Norway, to obtain a number of low horizontal tracks cross the ice edge for CO_2 exchange studies. The horizontal projection of the flight track is given in Figure 39. Total flight time was 9 h 20 min.

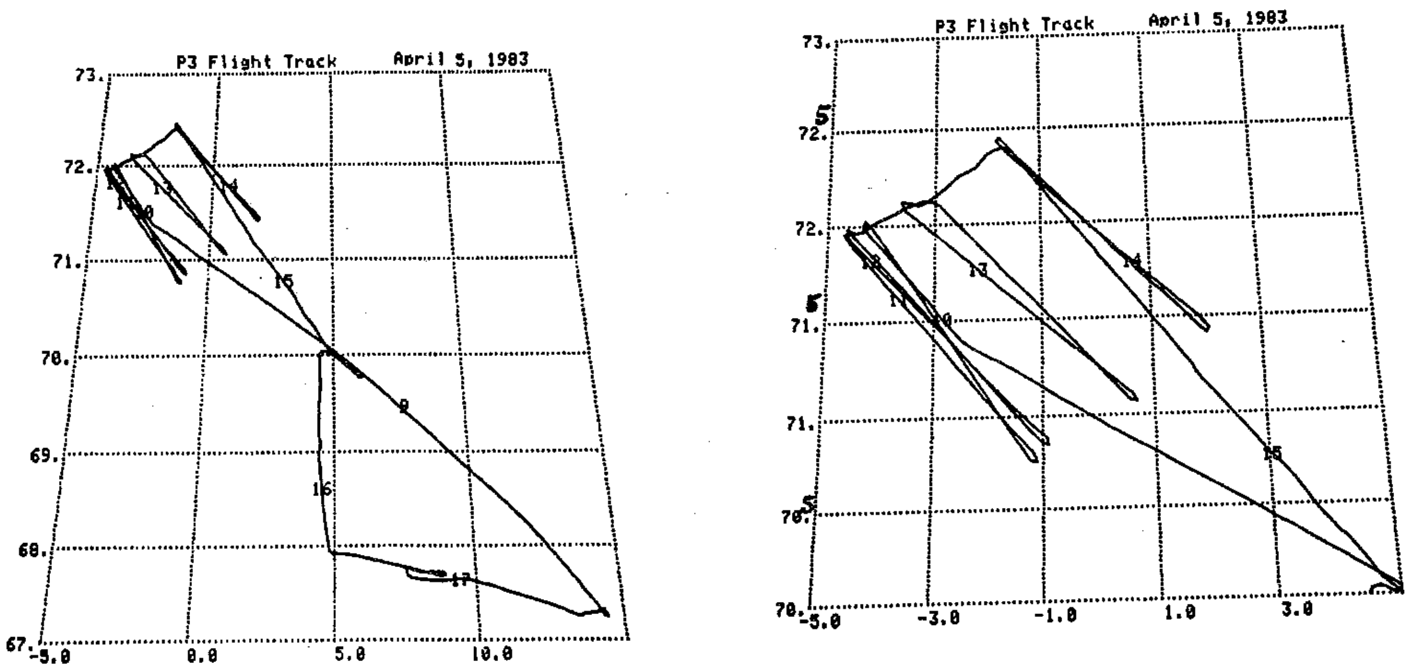

Fig. 39: Horizontal projection of the aircraft's flight track over the Norwegian Arctic, April 5, 1983.

10.2 Synoptic Situation

The surface pressure distribution was characterized by a cyclonic system over Great Britain and an anticyclone over Greenland (Figure 40). These two pressure systems created a zone of strong pressure gradients, and therefore of strong winds, across Iceland and Jan Mayen. At upper tropospheric levels (500 mb) a weak high-pressure ridge was located over the Norwegian and Greenland Seas (Figure 41).

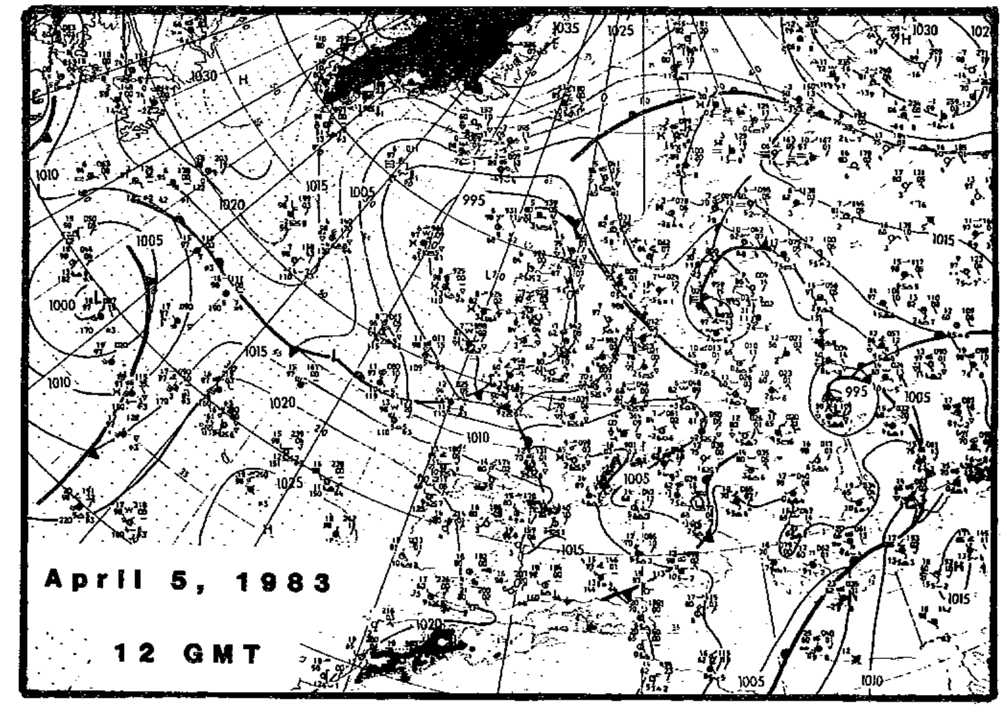

Fig. 40: The surface pressure (mb) distribution over the Norwegian Arctic, April 5, 1983, 1200 GMT (Deutscher Wetterdienst, 1983).

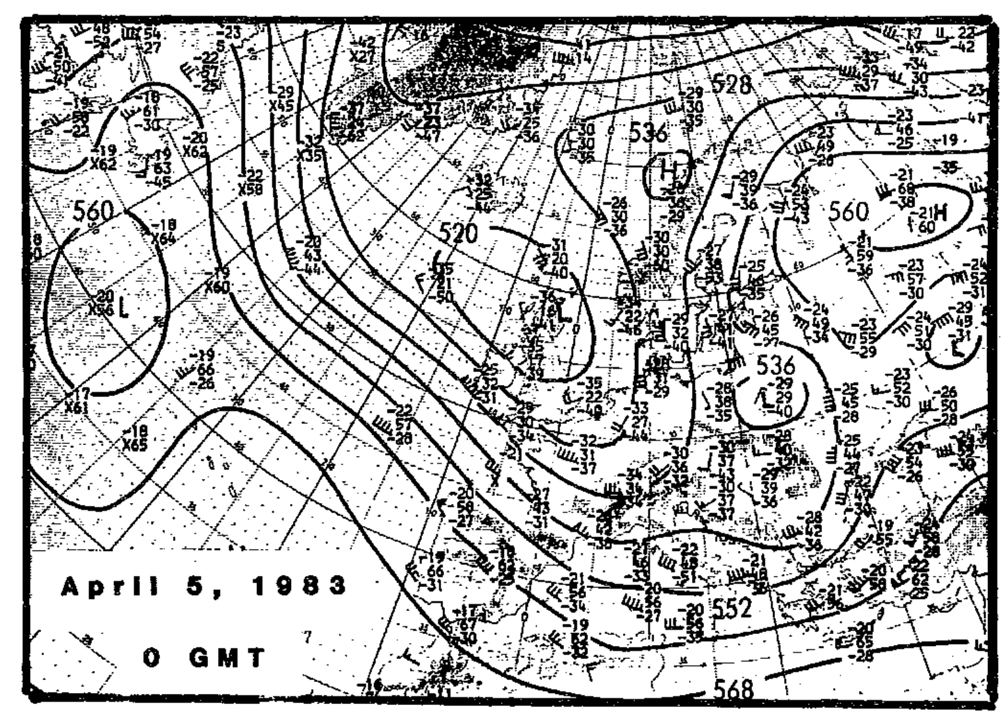

Fig. 41: The 500-mb pressure height (geopotential decameters) distribution over the Norwegian Arctic, April 5, 1983, 0000 GMT (Deutscher Wetterdienst, 1983).

10.3 Flight Log

8:10	take off
8:10-8:41	ascent
8:20	darker haze bands visible in contrast to white Ci clouds, 7/8 Ac, 3/8 Ci
8:30	no more haze visible until the end of the flight, 7/8 Ac, 7/8 Ci
8:41-9:04	horizontal track at 425 mb within upper tropospheric air
8:50-9:50	8/8 Ac top at 760 mb, 4/8-8/8 Ci at 425 mb
9:04-9:54	descent
9:54-14:47	various horizontal tracks at 978-1012 mb across the ice edge and above/within marine boundary layer
10:00-14:50	4/8-7/8 Sc
14:47-14:53	ascent
14:53-15:20	horizontal track at 754 mb above the boundary layer with maritime air
15:20-15:29	descent

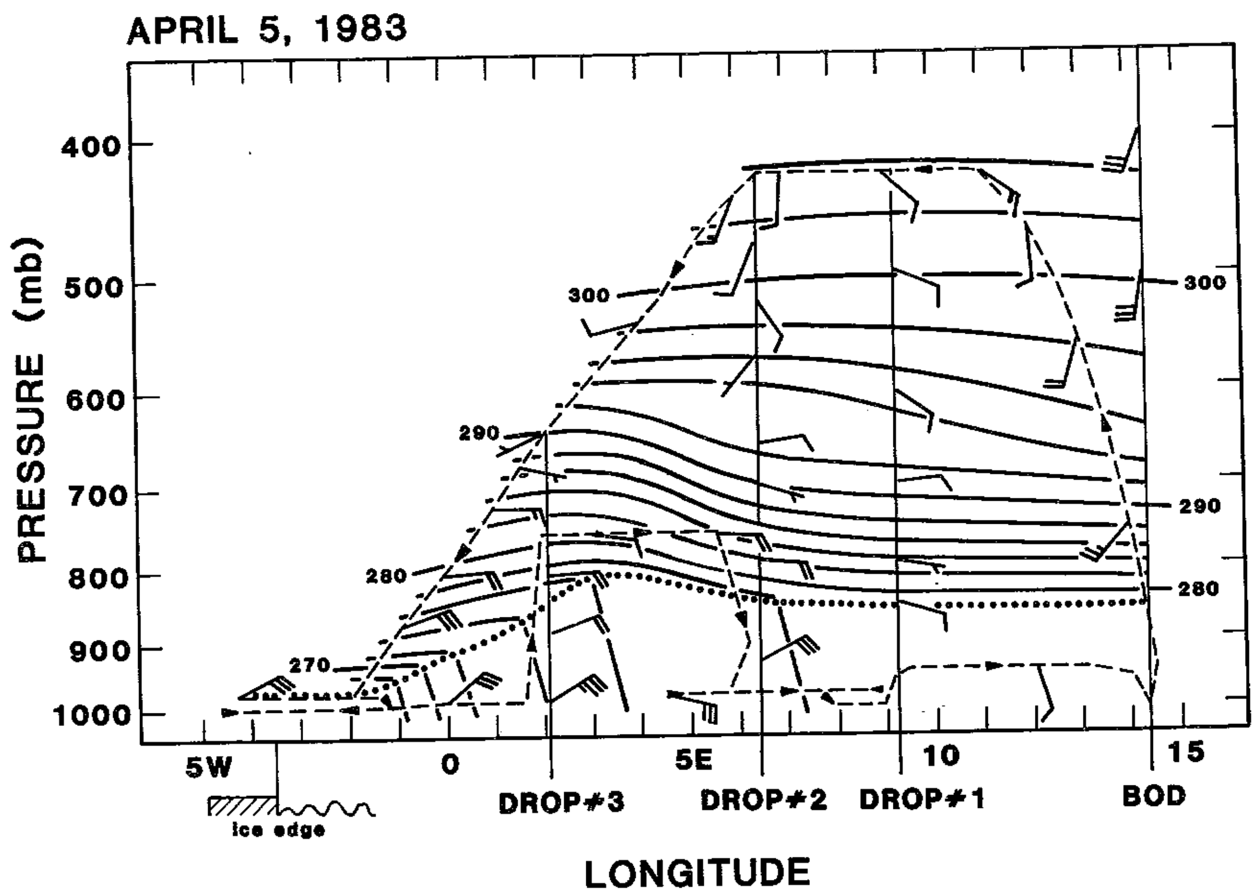

Fig. 42: Longitude-altitude cross section of potential temperature (K) and wind (kt), April 4, 1983. The aircraft flight track is indicated by the broken line. April 4, 1983. The top of the marine boundary layer is indicated by the dotted line.

15:29-17:36	various horizontal tracks between 950 and 1010 mb within the marine boundary layer
15:30-16:30	6/8-8/8 St
16:40-17:10	6/8 Cu
17:20	4/8 Ac, clear ahead toward Bodo
17:36	Bodo

10.4 Atmospheric Cross Section

A longitude-altitude cross section of potential temperature (Figure 42) was constructed along the flight track on the basis of radiosonde data obtained over Bodo (BOD); data from dropsondes released by the aircraft at about 9° E, 6° E, and 2° E; and data recorded by the aircraft along its flight track.

There are no strong horizontal temperature gradients within the middle troposphere. A marine boundary layer dominates the lower troposphere, and its height rises toward the east as one moves away from the ice edge located at about 4° W.

11. AGASP Flight No. 11 (April 10, 1983)

11.1 Mission Type

The aircraft flew northwestward from Bodo to obtain several low-level horizontal tracks for CO_2 measurements over the open water and across the ice edge under synoptic conditions of low wind speeds. The horizontal projection of the flight track is given in Figure 43. Total flight time was 9 h 35 min.

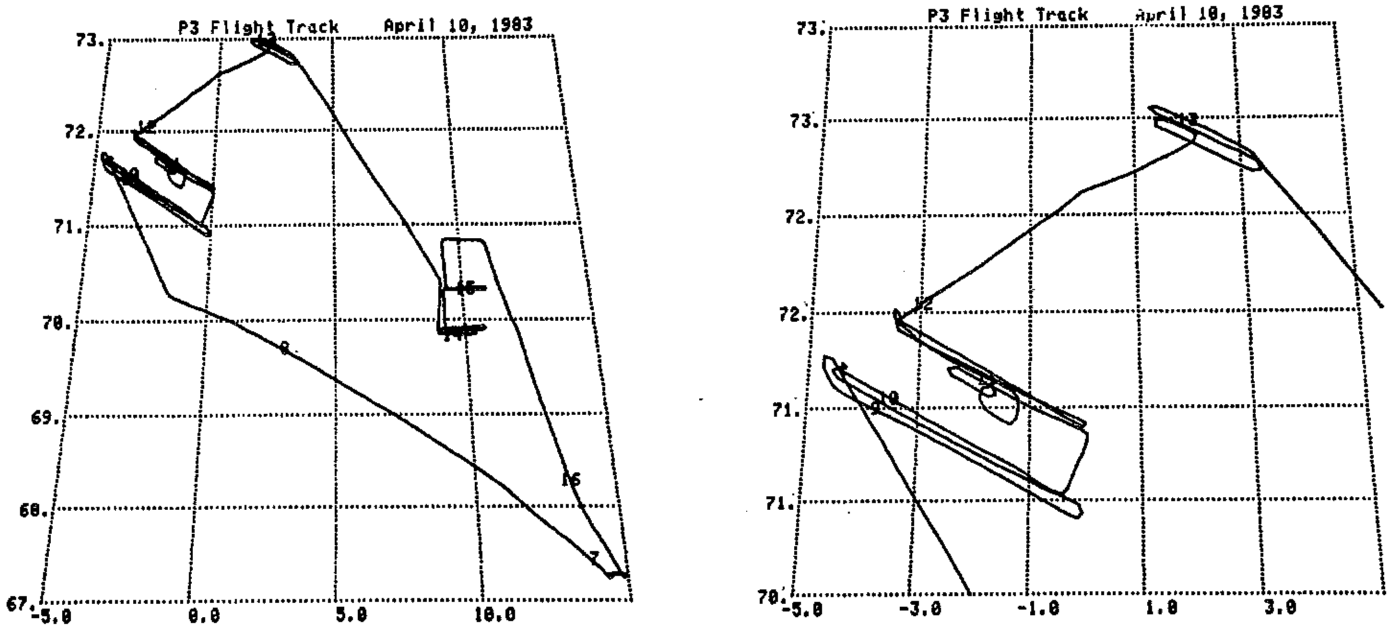

Fig. 43: Horizontal projection of the aircraft's flight track over the Norwegian Arctic, April 10, 1983.

11.2 Synoptic Situation

The surface pressure distribution was characterized by a cyclone over Great Britain, a cyclone over northeastern Scandinavia, and a high-pressure ridge reaching from the North Atlantic across Iceland (Figure 44). Hence, the area studied was located in a quasi-undefined flow regime. At upper tropospheric levels (500 mb) no significant pressure gradients existed across the Norwegian-Greenland Seas (Figure 45).

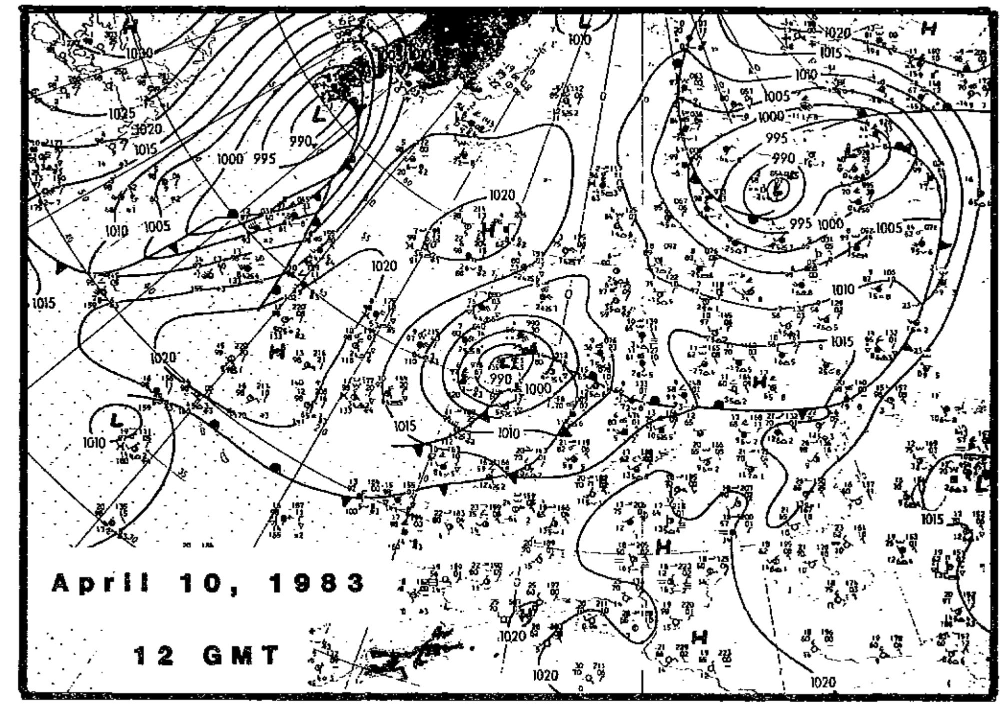

Fig. 44: The surface pressure (mb) distribution over the Norwegian Arctic, April 10, 1983, 1200 GMT (Deutscher Wetterdienst, 1983).

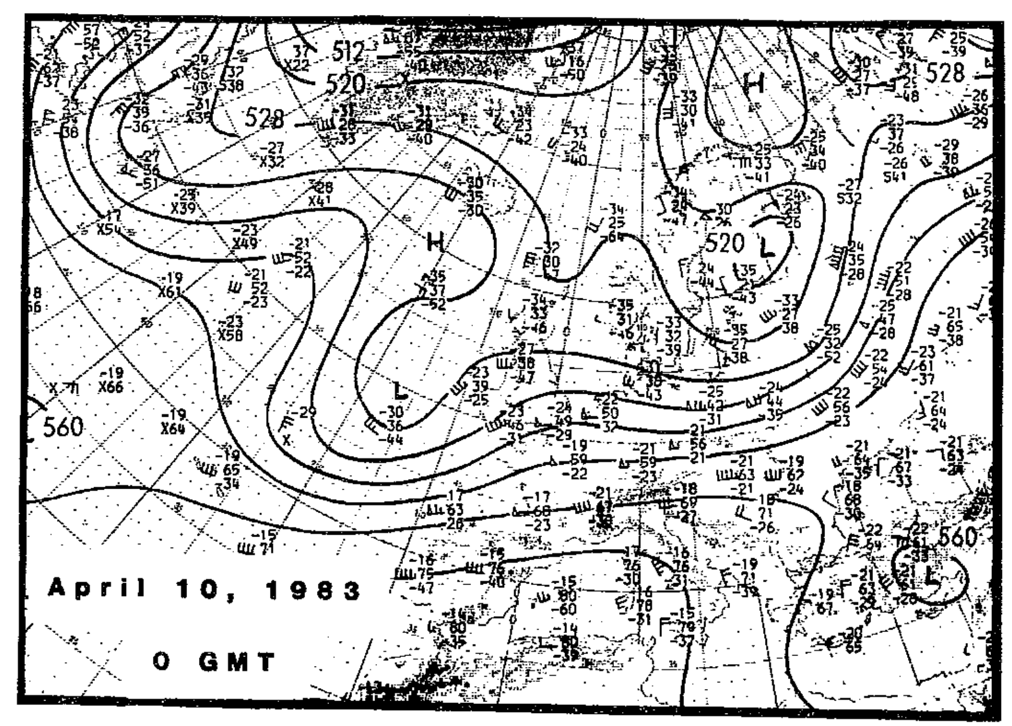

Fig. 45: The 500-mb pressure height (geopotential decameters) distribution over the Norwegian Arctic, April 10, 1983, 0000 GMT (Deutscher Wetterdienst, 1983).

11.3 Flight Log

6:50	take off
6:50-7:18	ascent
7:18-7:58	horizontal track at 425 mb within upper tropospheric air
7:39	haze layers below
7:58-8:18	descent
8:18-11:55	several horizontal low-level tracks within the marine boundary layer across the ice edge
11:55-12:00	ascent
12:00-12:21	horizontal track at 873 mb above the marine boundary layer
12:21-12:34	descent
12:34-13:05	several horizontal low-level tracks within the marine boundary layer over open water
13:05-13:24	ascent
13:19	climbing out of the marine boundary layer through clouds into a haze layer

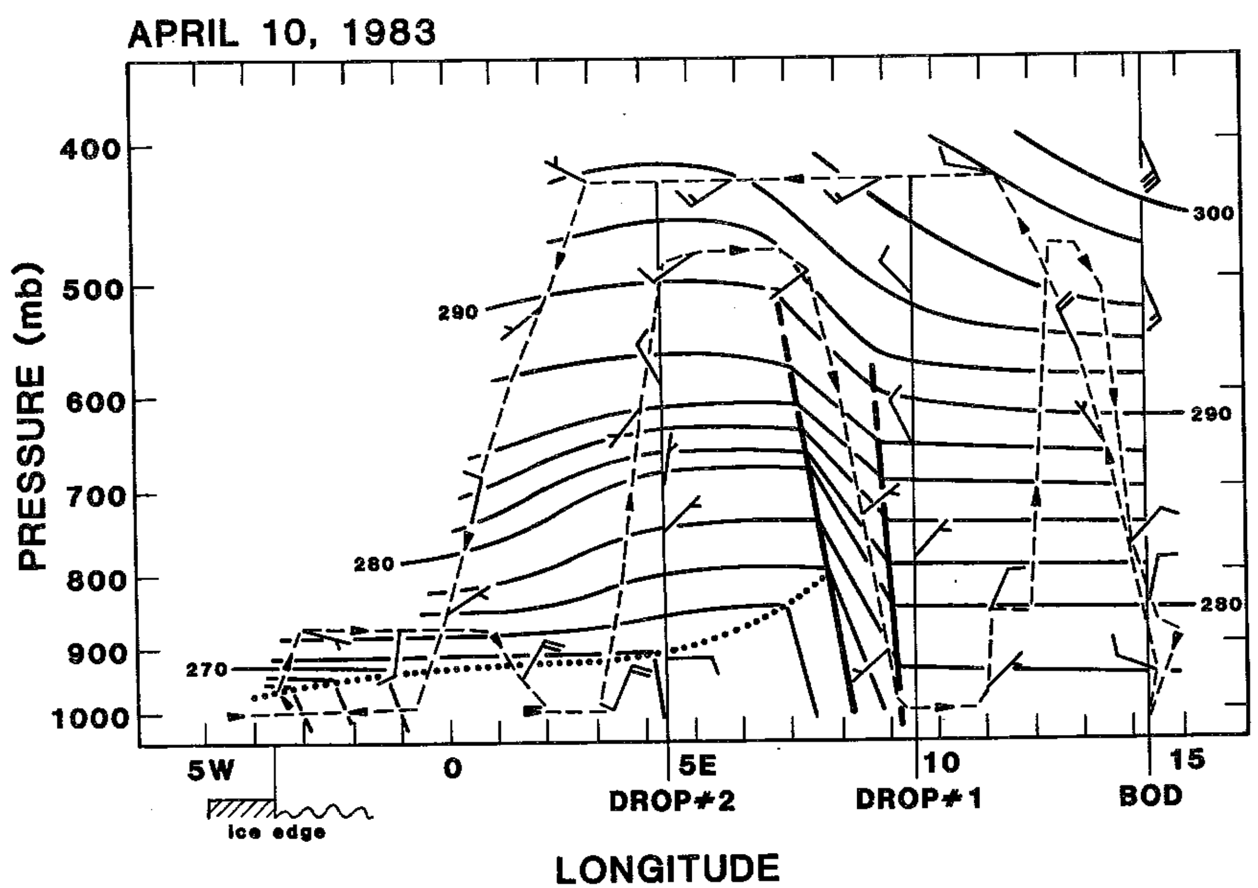

Fig. 46: Longitude-altitude cross section of potential temperature (K) and wind (kt), April 10, 1983. The aircraft flight track is indicated by the broken line. The top of the marine boundary layer is indicated by the dotted line, and the tropospheric front by the thick solid line.

13:24-13:33	horizontal track at 476 mb within upper tropospheric air
13:33-13:50	descent
13:50-15:23	several horizontal low-level tracks east of the frontal zone
15:23-15:47	ascent
15:47-16:26	final descent, Bodo

11.4 Atmospheric Cross Section

A longitude-latitude cross section of potential temperature (Figure 46) was constructed along the flight track on the basis of radiosonde data obtained over Bodo (BOD); data from dropsondes released by the aircraft at about 10 °E and 4 °E; and data recorded by the aircraft along its flight track.

The cross section is characterized by a tropospheric frontal system at about 9 °E belonging to the cyclonic pressure system over Scandinavia. West of the front, the lower troposphere is characterized by a marine boundary layer, whose height rises eastward as one moves away from the ice edge.

12. AGASP Flight No. 12 (April 12, 1983)

12.1 Mission Type

The aircraft flew from Bodo, Norway, westward across the Atlantic back to the United States. Between Iceland and Greenland, the Icelandic cyclone was penetrated at upper tropospheric levels and its characteristics studied by releasing nine dropwindsondes (Shapiro, 1985).

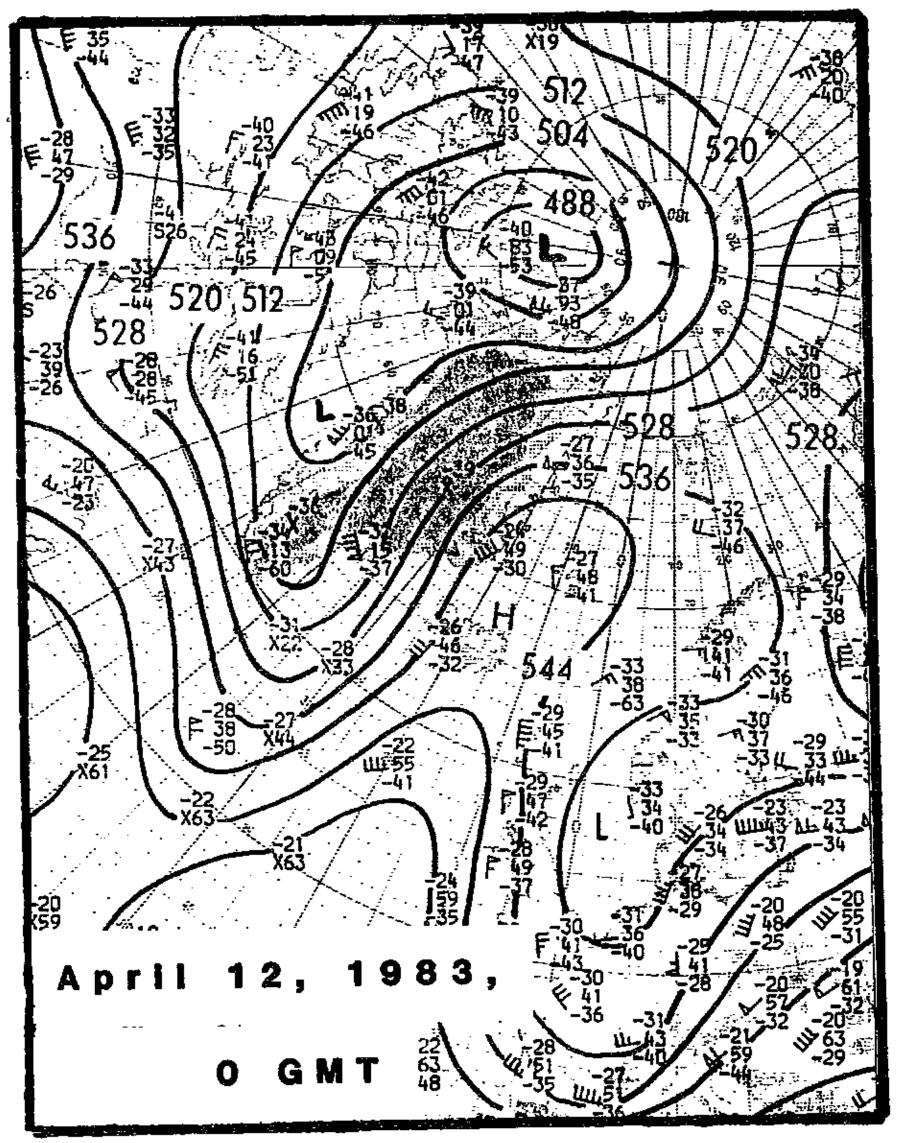

Fig. 47: The 500-mb pressure height (geopotential decameters) distribution over the Norwegian Arctic, April 12, 1983, 0000 GMT (Deutscher Wetterdienst, 1983).

12.2 Synoptic Situation

The upper tropospheric pressure distribution at 500 mb was characterized by a high-pressure ridge over the North Atlantic extending over Iceland, and a strong Baffin Island cyclone extending to the southern tip of Greenland (Figure 47). Hence, over the area studied, a zone of strong pressure gradients was present.

12.3 Atmospheric Cross Section

A longitude-altitude cross section of potential temperature and wind speed was constructed on the basis of radiosonde data obtained over Keflavik (04018), Angmagssalik (04360), and Narssarssuaq (04270); data from nine dropwindsondes; and data recorded by the aircraft (Figure 48).

The main feature of the cross section is the presence of two tropopause folds, one reaching as low as 800 mb near Iceland, the other reaching lower than 400 mb near Greenland. The tropopause folds are flanked by a westerly jet to the west and by a southeasterly jet to the east.

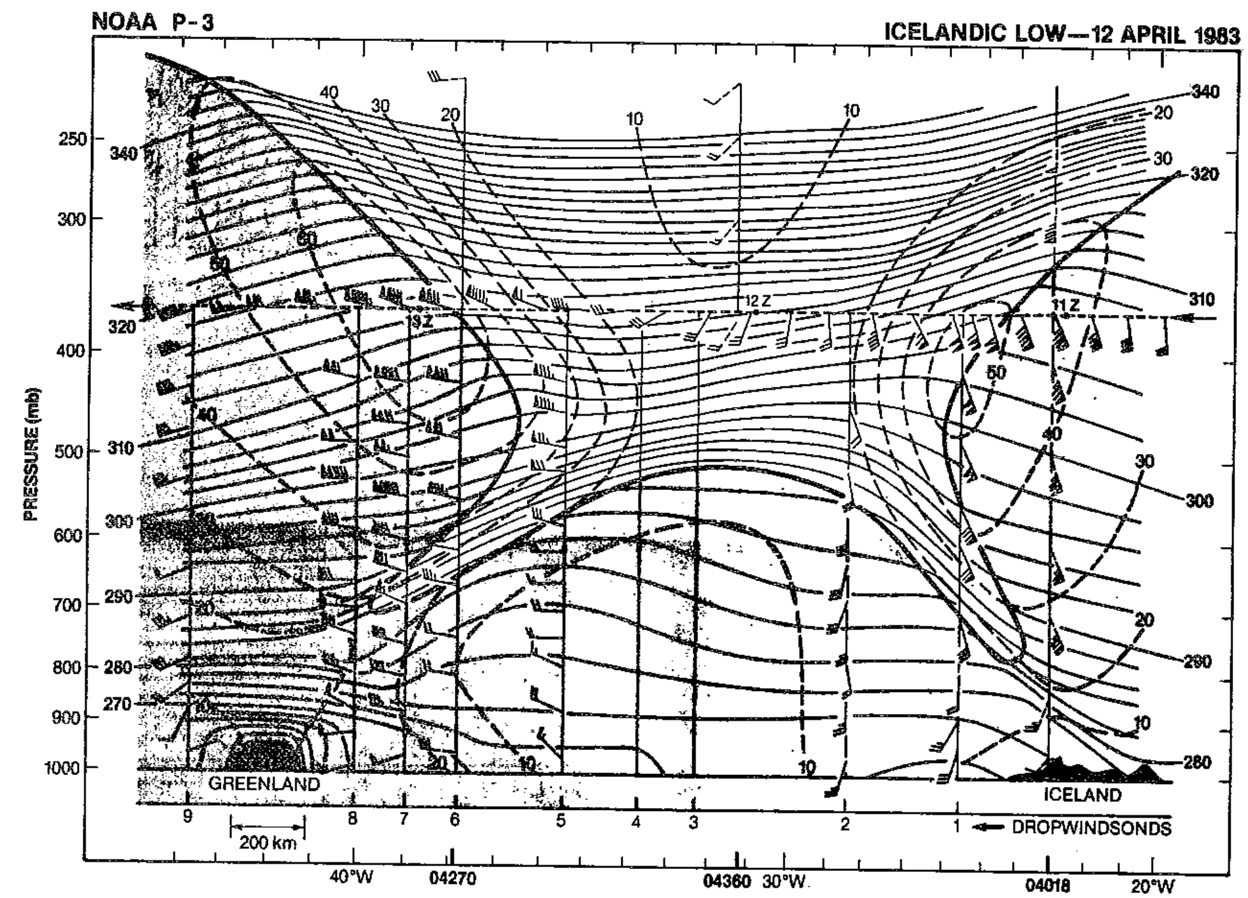

Fig. 48: Longitude-altitude cross section of potential temperature (K, solid isolines) and wind speed (m/s, broken isolines) between Iceland and Greenland, April 12, 1983 (Shapiro, 1985). The aircraft flight travel is indicated by the broken line. The two tropopause folds are indicated by the thick solid lines projecting deep into the troposphere.

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